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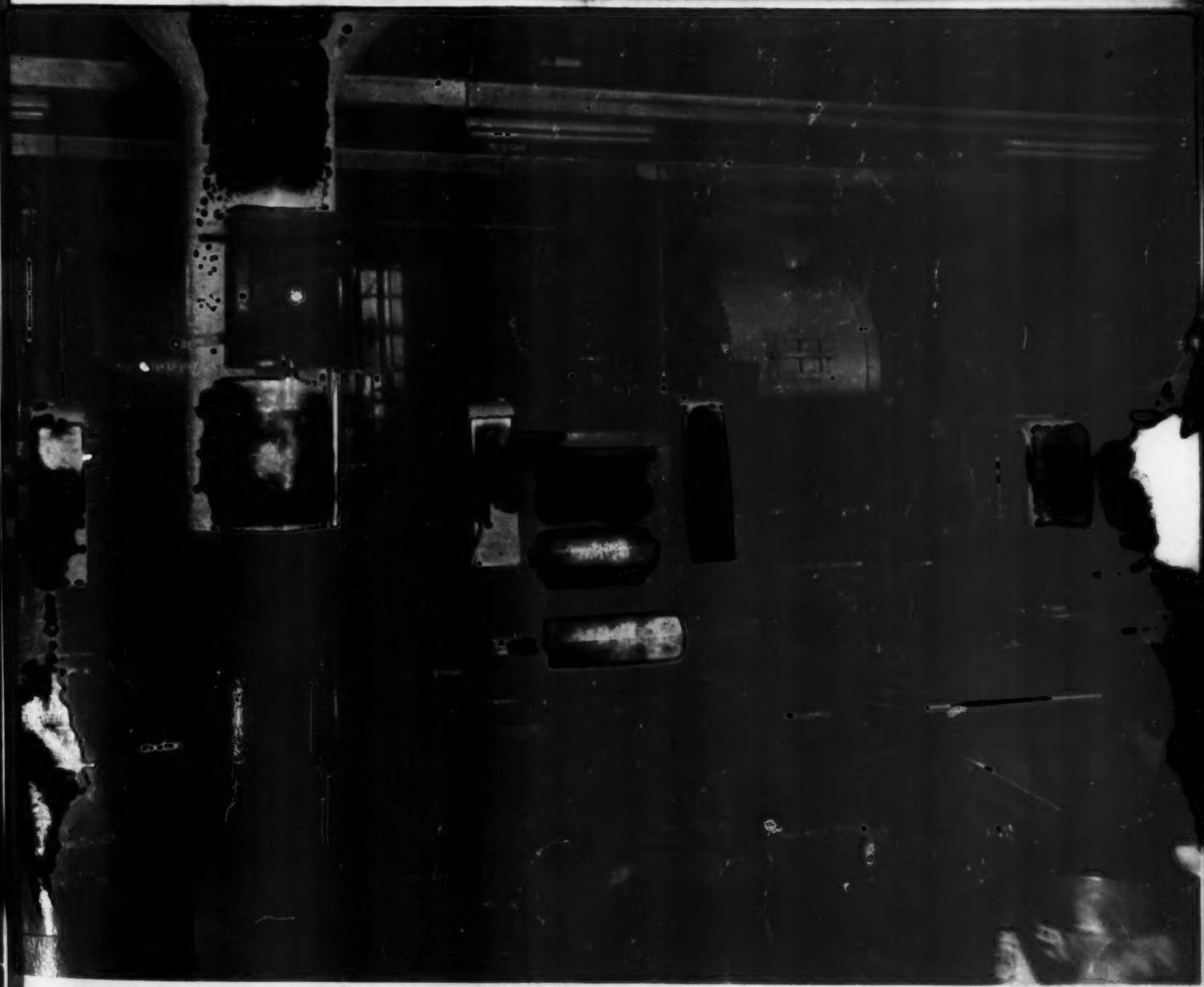
PRODUCT ENGINEERING

JANUARY, 1946



In this issue: **PLASTIC RESINS AS PROTECTIVE COATINGS**

NICKEL STEELS *combine...*

XCEPTIONAL MECHANICAL *and* FABRICATING PROPERTIES

4330 Nickel chromium molybde-
alloy steel was adopted for Curtiss
eller blades because of its high
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to properly harden SAE 4330 for
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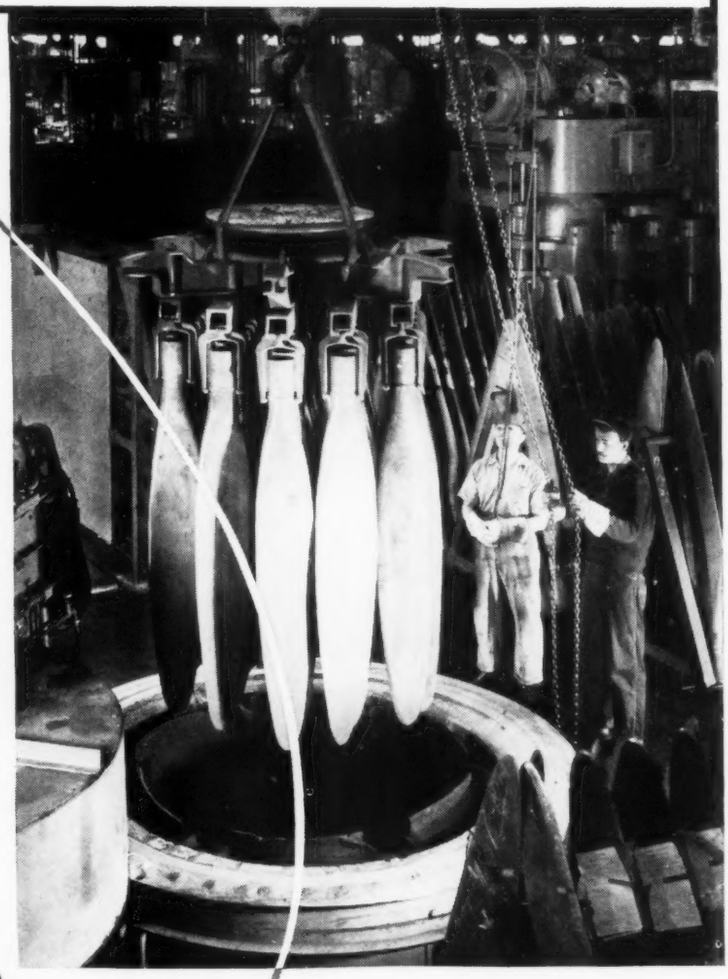

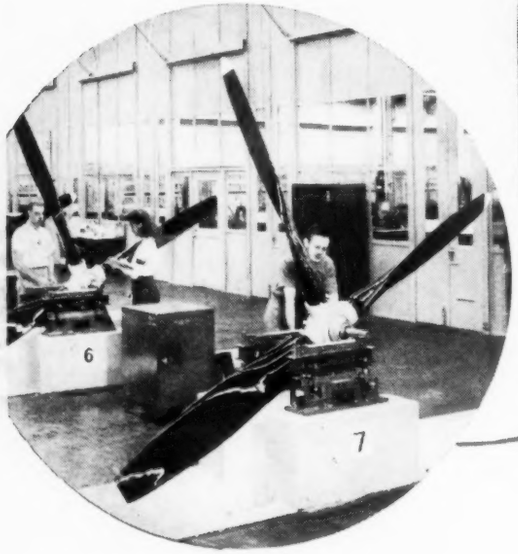

Curtiss Propeller Division of Curtiss-Wright Corporation, one of the largest producers of constant speed propellers, fabricates blades by welding two plates of SAE 4330 into a hollow unit that permits weight saving over solid blades of light metals.

Inquiries on the use of Nickel alloy steels or other alloys containing Nickel in your products or equipment, are invited.

INTERNATIONAL NICKEL COMP

PRODUCT ENGINEERING

JANUARY, 1946
VOL. 17 NO. 1

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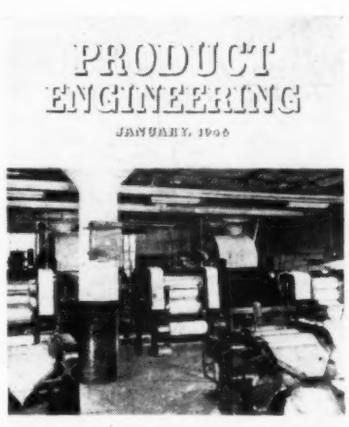

COVER—Roller mills are used to mix pigments with plastic resins. Kodachrome courtesy Finishes Division, Interchemical Corporation.

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IN THIS ISSUE

Plastic Resin Finishes

Considerable confusion has existed in engineers' minds over just what "plastic paints" are and their relative comparison with other finishes. As an aid in evaluating the various available types, Paul O. Blackmore gives a complete analysis of resin-based coatings and specific discussions on applications of the various finish types in "Plastic Resins as Protective Coatings," beginning on page 1. The article, illustrated in four colors, discusses phenolic, alkyd, nitrocellulose, urea, melamine, polystyrene, vinyl, vinylidene chloride and silicone-base resin paints.

Synthetic Rubbers—II

In the November issue, a 16-page special report covered properties, characteristics and applications of Butyl, acrilonitrile and GR-S elastomers. In this issue, see page 59, the report is concluded with similar articles on Neoprene and Thiokol. A brief review of the first section is also included.

Friction Brake Linings

When selecting a specific type of brake lining for a particular application, the engineer has a choice of numerous suitable materials. Hence, the review of these materials, prepared by the staff of PRODUCT ENGINEERING is presented on pages 39-43. Various types of brake linings are reviewed and the selection of the correct type in the design of brakes is discussed. Data on coefficients of friction are included.

Bearing Design for High Speed

Conventional machine design methods are not applicable to high-speed machines such as gas turbines, generators and superchargers. Until new analytic methods and extensive expe. nce are available, new high speed designs must be guided by a sense of "feel." Zola Fox, formerly assistant to chief engineer, Union Aircraft Products Corporation, see page 8, presents much pertinent information concerning the requirements of bearings, nut locking devices, and thrust collars for high speed superchargers.

Ductile Permanent Magnets

Many times, the engineer is hampered in the design of magnets because most magnet materials are not easily machined or shaped to close dimensions. In an article by J. H. Goss, beginning on page 44, some of the newer ductile permanent magnet materials are described.

Applied Finishes Standarization

Standards are playing an expanding role in the fields of engineering and manufacturing. They will ultimately affect the production and sale of all products. One important phase of standardization, that of applied finishes, is discussed by S. B. Ashkinazy, Standards Engineer, Materials and Processes, Sperry Gyroscope Company, see page 24. The discussion sets forth selection of finishes, writing procurement and application specifications, and securing company cooperation.

Radar a Peacetime Product

Long in the public eye, the application of radar to postwar uses was inevitable. Emerging from military sponsorship, radar makes its appearance as an "Electric Navigator," in reality a marine obstacle detector. Beginning on page 69, the Navigator is discussed and its method of operation described.

Releasing Advance Engineering Data

In the sixth of a series of articles on drafting room organization, James E. Thompson, chief engineer, Booth Manufacturing Company, see page 54, discusses stop-work orders and methods of permitting manufacture while drawings are under revision.

Methods of Actuating Brakes

In the many methods of brake actuation in use today, designs range from simple mechanical linkages to complex air-hydraulic systems complete with air compressors. On page 48 of this issue, some of the types utilizing electricity, magnetism and vacuum as a source of power are illustrated and described.

Inserts for Molded Plastic Parts

Numerous factors enter into the proper design and use of inserts in molded plastic parts, notably problems of anchorage, thickness of material around inserts, allowable tolerances on dimension, floating, crushing and the like. Previous issues of PRODUCT ENGINEERING have covered this subject in some detail. In this issue, pages 29-38, are presented design standards for inserts covering both screw-machined and cold forged types, based on industry research by the Technical Committee of the Society of the Plastics Industry.

Shaft Design

To simplify the determination of the correct size for solid round shafts loaded both in torsion and in flexure, a nomogram has been developed by Carl P. Nachod. This chart, appearing as a Reference Book Sheet on page 87 of this issue, has a double scale, to extend its use over a wide range.

Kinetic Energy of a Revolving Body

The mathematical determination of the kinetic energy of a revolving body is a somewhat lengthy operation, especially if the body in question is non-homogenous. The Reference Book Sheet on page 88 of this issue provides a nomogram for this calculation, utilizing the comparison solid method of determination.

FEBRUARY HIGHLIGHTS

Calibration Ring Design, by Given Brewer. Analysis of stresses set up by deflections in calibration rings having a rectangular cross-section.

Oil Seals in Superchargers, by Zola Fox. Methods for preventing oil leakage through openings for shafts in gear cases and bearing housings of high speed superchargers.

High Nickel and Nickel Copper Ni Resist. The properties of these alloys are fully described for use by designers and design engineers.

Tolerances for Molded Plastics Parts. Specific recommendations for coarse, standard and fine tolerances to be specified on moldings of phenolic, urea, melamine, acetate, butyrate, ethyl cellulose, metacrylate and polystyrene plastics.

Theory of Color Application. Discussion of basic principles in use of color on machinery, illustrated in four-colors.

Glass-cloth Melamine Laminates. These new products, used widely by the Navy during the war, are now being adapted to industrial applications.

Design Analysis for Rotary Pumps, by Warren E. Wilson. Development of a design method for proportioning the parts and clearances of rotary pumps to obtain maximum efficiency.

PRODUCT ENGINEERING

JANUARY, 1946

Plastic Resins As Protective Coatings

PAUL O. BLACKMORE
Director, Products Engineering and Development
Interchemical Corporation, Finishes Division

Applications, limitations and future possibilities of protective coatings formulated with liquid plastics. Alkyds, phenolics, ureas, melamines, vinyls, vinylidene chlorides, polystyrenes, and silicones are discussed from the standpoint of their utility in commercial finish formulations.

IT IS HOPED that this discussion will help to clear up some of the confusion that surrounds the so-called "plastic paints." Certain types of advertising have created an aura of glamor and mystery about these materials which, in reality, are quite commonplace. Having a plastics conscious public, it is quite natural to expect everyone who has the remotest reason for doing so, to attempt to climb upon the plastics band wagon and to bask in the limelight of its glamor, thereby reaping whatever profits may accrue. Admitting then, for the sake of argument, that there is such a thing as "plastic paint," this article goes a step further and shows that plastic paints are as old as plastics themselves and that nothing has been brought forth in recent times to warrant over-enthusiastic performance claims.

Plastics and Paints Allied

From a raw materials standpoint plastics and paint are so closely allied that an expert in one can easily be an expert in the other. Nitrocellulose, ethyl cellulose, aceto butyrate, cellulose acetate, phenol formaldehyde, urea, melamine, methacrylate, polystyrene, and others are equally familiar to either the plastics or the protective coatings technician. In the application, however, of these basic resins lies the essential difference between plastics and paints.

The plastics technician takes the above raw materials, reduces them to a finely powdered state, shapes them in a heated mold or extrudes the molten plastic through a hot die. Sometimes he puts them into solution and impregnates paper or fabrics with them, subsequently laminated into sheets, rods or tubes by heat and pressure.

The protective coatings technician puts the same raw materials into solution and atomizes them by passing them through a spray gun. Or he may use a brush, a dip tank, or a roller coater. In any event, whether applied by fusion and subsequent freezing or by deposition from a solvent, the end result is exactly the same from a chemical standpoint.

Having established this analogy between plastics and protective coatings, it is not hard to see that technical progress in one immediately aids the progress of the other. The question of whether the hen came before the egg is unimportant as long as there are plenty of both hens and eggs to go around. Similarly, whether or not a product finds its initial use in plastics or paint is unimportant as long as technicians remain alert to its possibilities and potential applications in their respective fields.

The future of the protective coatings industry is in the field of synthetic resins. Call them paints or liquid plastics as you choose. They have been and will continue to be with us for many years.

Plastic Finishes in Retrospect

Nitrocellulose is generally conceded to be the first plastic. It was discovered by Schonbein in Basle, Switzerland, in 1846. However, he made no commercial use of his discovery. It remained for Wesley Hyatt, an American, to produce the first commercial plastic, Celluloid, in 1868, from nitrocellulose and camphor. This material in a few years found wide commercial use.

The development of nitrocellulose lacquers was retarded by the fact that the early nitrocellulose yielded solutions of extremely high viscosity and low solids. Furthermore, good nitrocellulose solvents, such as ethyl, butyl, and amyl acetates, were not available in commercial quantities or at prices that would make nitrocellulose lacquers an attractive buy. The first world war stimulated research and production on both nitrocellulose and solvents, and both became plenti-

Fig. 1—Pressure lubrication equipment finished in Polymerin, a urea-alkyd baking enamel, durable, and resistant to oils.

ful in the postwar era. Nitrocellulose lacquer reduced the time required for finishing an automobile body from days to hours and provided new standards of beauty and durability, but no one called it liquid plastic.

Nitrocellulose lacquers really came into their own in the late nineteen twenties. Improvements in gloss, build, and durability were made possible by the advent of innumerable new synthetic resins and plasticizers. The procession of synthetic resins is continuing, and improvements have also been made in the stability and solubility of the nitrocellulose itself. Therefore, postwar lacquers will reach a new high in clarity, durability, high solids, and application.

Higher solids at spraying viscosity will contribute to lower costs. In addition, the expansion of nitrocellulose manufacturing facilities to meet wartime needs has created a capacity in excess of the peacetime demand which should result in lower prices. This is also true of the solvents and diluents used in compounding the thinners. Synthetic toluol from petroleum is now available in ample quantities and will divorce toluol from the steel mill activity formerly the index of price and availability.

Thus, there is a genuine prospect for large volumes of high quality nitrocellulose lacquer at a low cost, which may create formidable competition for some of the newer synthetic baking finishes which began to make serious inroads on the lacquer market before the war.

Nitrocellulose lacquers are versatile finishes. They may be obtained either clear or pigmented, glossy or flat. Color range is practically unlimited. For rigid surfaces such

as metal or wood, they may be made hard and marproof, yet with excellent adhesion and resistance to shock. For fabrics, leather, rubber goods, paper, they may be made flexible enough to stand creasing without cracking and distensible enough to stretch and contract with the substratum on which they are applied. They can be made resistant to moisture, alcohol, gasoline, vegetable, animal, or mineral oils, mild acids and alkalies. One of their biggest advantages is that they dry purely by solvent evaporation, requiring no expensive oven installations. (The exceptions to this are the new so-called synthetic baking lacquers in which higher solids are achieved by the addition of substantial quantities of oxidizable or polymerizable synthetic resins.)

Lacquers dry dust free in a very few minutes. However, overnight air drying is usually required to achieve film hardness that is adequate to permit packaging or stacking the finished articles without danger of film damage. As mentioned above, lacquers may be made in an almost unlimited range of colors, and their color retention is good, provided, of course, the pigments themselves have good permanence and the modifying resins and plasticizers do not contribute to a change in color.

It has been stated that the trend in nitrocellulose lacquers has been to higher solids. Pre-war lacquers, both clear and pigmented, sprayed at from 15 to 25 percent solids at the gun. Post-war lacquers will spray at 30 to 35 percent, and if heat is used to aid in lowering the viscosity, 40 percent or better may be reached.

Higher solids have been achieved by a combination of several things:

1. The use of nitrocellulose much lower in viscosity than was thought practical before the war.

2. The use of higher ratios of synthetic resins with the nitrocellulose.

3. The use of stronger solvent combinations.

4. The use of heat to further reduce the viscosity.

Equipment is currently available for heating the lacquer and feeding it to the gun at a temperature of about 150 deg. F. Hot lacquers must be especially formulated inasmuch as a carefully balanced thinner formula is essential to their successful performance.

Although the achievement of higher solids will reduce the importance of the principal objection to nitrocellulose lacquers, it will not completely eliminate it, because competitive synthetic enamels will spray cold at a higher solids content than has yet been achieved in lacquer.

Another disadvantage generally attributed to nitrocellulose is that of fire hazard. In the opinion of the writer, the hazard has been over-emphasized. Any finish deposited from volatile organic solvents is a fire hazard. The degree of hazard involved is a function of the flash point of the solvents being used. The flash point of any combination of solvents will be the flash point of the most volatile component. Thus, a varnish or a synthetic enamel containing toluol is just as liable to ignite from a stray spark or from static electricity, as is a lacquer with the same flash point. Admittedly, once ignited, the lacquer will burn more furiously than the varnish or enamel, which makes little difference if modern fire-fighting equipment is available. It is true, however, that the products of combustion from a lacquer fire are much more toxic when inhaled. From the standpoint of spontaneous combustion, lacquers are less liable to ignite than varnishes or enamels unless the lacquer contains a large proportion of an oxidizing oil or resin.

Prediction for Lacquers

It is predicted that nitrocellulose lacquers, the first liquid plastics, will retain a major share of the wood furniture market. While some automobile manufacturers have turned to synthetic enamels, others still believe the lacquers are the ideal automotive finish. The advantage of synthetic enamel is principally in the elimination of sanding and polishing costs, and it is probable that it chalks more slowly on exposure, thus causing an uncared-for car to look better during its first year of life. From then on, however, when the owner starts to polish, lacquer is much more easily restored to its pristine luster. Synthetic enamels remain hazy due to minute scratches from the rag and the polishing compound.

Pyroxylin-coated fabrics will continue to be made and sold in large quantities, although vinyl resin coatings will capture a portion of that market.

Lacquer coated labels will continue to consume large amounts of nitrocellulose lacquer. Hot-melt resin coatings will claim a share.

Metal stampings and castings, including non-ferrous metal die castings, will use lacquers to a considerable extent, although the new speed-bake enamels will compete strongly for that market. It is not expected that lacquers will be used to any great extent on household appliances such as refrigerators, stoves, washing machines, and kitchen cabinets. The speed-bake enamels provide better gloss and fullness, as well as better initial whiteness and color retention.

Phenol-Formaldehyde Liquid Plastics

Nineteen hundred and nine was a great year in Yonkers, New York, for it marked the discovery, in that city, of the first thermosetting plastic, discovered by Dr. Leo Baekeland in causing phenol to react with formaldehyde under certain conditions. The reddish-brown, syrupy material obtained, upon further heating, ultimately converted to a hard, glass-like, infusible, insoluble solid.

Phenolic resins now have come to include those made with aldehydes other than formaldehyde, such as furfural; and phenols other than carbolic acid, such as cresol, xylenol, resorcinol, etc. They are characterized by good dimensional stability, resistance to water, acids, alkalies, oils and gasoline, and by high electrical resistance which has stimulated wide usage for electrical insulation. They are dark in color, and are subject to further discoloration on exposure to sunlight. Therefore, their use is limited to colors other than whites.

The original phenolic plastic resins were soluble in water before curing but were not soluble in organic solvents. Applied in thin films, they were brittle and lacked adhesion. Accordingly, a program of research was directed toward supplying these missing links. As a result, oil-soluble and oil-reactive phenolic resins were developed. The presence of the oil in the film supplied the flexibility and adhesion that were lacking in the original resins, and, in addition, the varnishes so prepared were soluble in organic solvents. With this development new highs were reached in durability, water and chemical resistance, film hardness, and drying speed. Many modifications of these phenolic resins appeared, and because of the unusual properties they imparted to paint and enamel films, they quickly took the spotlight away from the natural resins that had held the center of the stage for many, many years.

Non-oil-reactive, alcohol-soluble thermosetting types find wide usage in the production of sanitary linings for food and beverage containers. Applied by roller coating on flat sheets of tinplate, the films are cured at suitable time-temperature cycles, after which the tin cans are fabricated. The coatings withstand not only the forming and crimping operations of can manufacture, but also the rigors of steam pressure cooking, sterilization.

Phenolic resins serve also as interior protective coatings in metal five-gallon containers and drums to protect the metal from attack by the contents of the package. Many kinds of chemicals may be shipped in phenolic-lined containers. Frequently it is more important to keep the chemical free from contamination with iron than it is to keep the iron from being attacked by the chemical. These kit and drum linings are, when properly cured, resistant to organic solvents. Thus, a clear lacquer or a white enamel can be shipped without discoloration.

Because of their high dielectric value, coatings based on phenolic resins have found large usage for electrical insulation. The reddish-brown coating on motor armature windings is phenolic.

Because of their imperviousness to water and atmospheric moisture, phenolic resin coatings excel as primers on structural steel and are often used, pigmented with red lead, blue lead, and other corrosion inhibiting pigments, for painting of underwater

Fig. 2—Products decorated in the flat sheet, baked and subsequently fabricated.

structures such as locks and dams, or for the interior protection of water tanks.

Particularly resistant to corrosion by salt atmosphere, phenolic resin coatings were widely used as primers on the ships of the United States Navy. Of particular war-time interest were the fast-drying aircraft primers based on the so-called "gook" or dispersion resins. These resins were produced by reacting a phenolic resin with an oil (usually tung) and carrying the resulting varnish to an extremely high state of polymerization. The varnishes, actually carried to a state of complete gellation, were redispersed in colloidal form in organic solvents. In effect, this amounts to pre-drying the paint film under carefully controlled conditions before it is actually applied. The pre-dried film, like a lacquer, dries solely by solvent evaporation.

Aircraft primers formulated with these dispersion resins were dry to handle in one or two minutes, without heat, and could be re-coated with lacquer or enamel in five minutes. The resulting films were a trifle britle but performed satisfactorily on rigid surfaces.

Phenolic resin coatings will continue to be widely used as metal protective primers, insulating varnishes, can and drum linings, spar varnishes, etc. Color limitations and poor color retention will cause them to lose some of the purely decorative market to urea and melamine, although in two-coat work they will probably serve as undercoats for the latter.

Alkyd Resins

The alkyd resins enjoy a unique distinction. They are probably the only class of synthetic resins that were born into the protective coatings field and migrated later into plastics. Alkyds made their initial bow about the middle nineteen twenties and enjoyed a rapid and luxurious growth. During the war years they entered the plastics field as a component of the contact-pressure laminating resins based on monomeric styrene.

Alkyd resins are defined as the reaction product of a polybasic acid and a polyhydric alcohol. Usually the polybasic acid is phthalic and the polyhydric alcohol is glycerine. The glyceryl-phthalate resin so formed is a pale, glass-like and fairly insoluble substance, but when modified by vegetable oils or their fatty acids it becomes soluble in organic solvents. Glyceryl-phthalate has the unique property of being unusually resistant to the destructive effects of ultra-violet light. Hence, enamels formulated on an alkyd resin base have exceptionally good durability. The number of available alkyd resins is legion and they are still coming. Opportunities for modification are practically unlimited. For the phthalic component there may be substituted Carbic Anhydride, maleic and fumaric acids, succinic, adipic, etc. Glycerine may be replaced by ethylene glycol, manitol, sorbitol, pentaerythritol, and many others. Carbic Anhydride increases polymerization speed. Ethylene glycol serves to make the resin soft and non-drying. Pentaerythritol increases water resistance. Properties may be further varied by the amount and kind of modifiers.

With all the available permutations and combinations it is no wonder that the protective coatings technician is left a bit bewildered when it comes to selecting the proper resin to do a certain job.

As mentioned above, alkyd resin's first big job was on household refrigerators. It imparted a gleaming whiteness that lasted practically indefinitely and imparted a resistance to chipping and mechanical damage that, together with lower cost, soon caused a very high percentage of manufacturers to turn away from vitreous enamel for refrigerator exteriors. In addition, the new finishes resisted staining or softening by food acids.

The outstanding performance of these alkyd enamels resulted in a rapid enlargement of their usage. Higher solids, higher build and gloss, lower solvent costs, excellent durability and color retention made it look for a while as if nitrocellulose lacquers were to lose their place in the sun. However, these very same alkyd resins are largely responsible for the spectacular improvement in the lacquers which will help them to retain their share of the coatings market.

Alkyd resins will continue to be used in

large quantities after the war, particularly on household appliances. However, for the most part, they will be used in conjunction with urea and melamine resins which impart additional desirable properties as pointed out in later paragraphs. This trend started about 1937 and accelerated rapidly until the use of such finishes was curtailed by the war. It is predicted that alkyd resins will be used by themselves only for exterior and interior air drying architectural finishes.

Urea and Melamine

In 1937 users of industrial finishes were electrified by the announcement of a new speed-bake finish which cut baking cycles down to five minutes or less. Public reaction to this announcement was mixed. Some were certain that any finish which baked so fast must, of necessity, be brittle and lack adhesion. Others who had the courage to try the finish out, discovered that its hardness surpassed anything they had seen, whose gloss and fullness were the equal of anything available up to that time, whose clarity and permanence of color were beyond their fondest dreams, and above all, whose baking speed seemed to be limited only by how rapidly heat could be pushed into the object being baked—and all of this with excellent adhesion and flexibility!

For several years prior to the advent of this finish, a gaily colored lightweight plastic, known as "Beetleware," was attracting considerable attention. Beetleware was a resinous polymer of dimethylol urea, a reaction product of urea crystals and formaldehyde. Beautiful pastel shades were possible because the resin itself was essentially water-white in color, thereby imparting no discoloration whatsoever to the plastic.

Dimethylol urea polymer, like the early phenolic molding resins, was water-soluble but not organic-solvent soluble. Thus, it was unsuited for protective coatings. However, it was soon discovered that if dimethylol urea were further reacted with butyl alcohol it became solvent-soluble and compatible with alkyd resins which imparted to it the flexibility and adhesion that it lacked by itself. Thus, the process of polymerization which permitted the rapid molding of plastics was adapted to finishes.

A year or two after the appearance of urea resins in protective coatings, another newcomer, melamine, made its bow. Melamine still further reduced baking schedules, still further increased film hardness, and furnished improved heat resistance and water resistance. Today, these unusual finishes are already being used on refrigerators, washing machines, stoves, kitchen cabinets.

The coatings combine the toughness, adhesion, flexibility, and durability of the alkyds with the speed of cure, hardness, water and heat resistance, clarity, and color retention of the ureas and melamines.

During the war modifications of these finishes have been made which adapt them to use on wood furniture. In this case low temperature cures are effected by means of suitable polymerization accelerators or "catalysts." Baking cycles of 45 min. to one and one-half hr. at 140 deg. F. to 150 deg. F. are to be expected. The resultant finish is hard, marproof, alcohol proof, fingernail polish proof, and resists cold checking to a degree previously unheard of in a wood finish. These thermosetting wood finishes will not polish to a mirror-like surface, but a high gloss finish is not required or even desirable in 95 percent of the cases. The finishes have a distinct advantage in build over a nitrocellulose lacquer because they spray cold at 40 to 45 percent solids compared to nitrocellulose sprayed cold at 21 to 25 percent solids. Solvents are cheaper.

It is predicted that urea-alkyd and melamine-alkyd finishes will enjoy a long and healthy career and that they will surpass in volume usage any other single type.

Acrylic Resins

During the two World's Fairs at New York and San Francisco, a new transparent plastic was displayed. The plastic had the unique property of piping light around cor-

Fig. 3—Wood and fabric reproductions obtained with lacquers and finishes described.

Fig. 4—Metal coated inside and out with phenolic, alkyd or vinyl resins, and formed after finishing.

ners, in spirals, in knots, and in other spectacular ways. Known under the trade names "Lucite" and "Plexiglas," it was cautiously predicted by some that homes of the future might have a powerful central lighting source from which the light could be distributed to other points in the house by means of these transparent plastic rods.

The most commonly used acrylic resin is poly-methyl-methacrylate. It is a water-white, transparent, thermoplastic resin, soluble in organic solvents which adapts it to use in protective coatings. Methyl-methacrylate coatings are resistant to after-yellowing, and are also outstanding in resistance to moisture, alkalies, and dilute acids. Of particular interest to coatings technicians is resistance to yellowing when exposed to elevated temperatures. Exposure to temperatures of about 500 deg. F. produces only slight discoloration.

Clear methyl-methacrylate films adhere well to plated surfaces, and being water-white, do not contribute any discoloration to the plating. Thus, they are widely used in clear finishes for polished metals. Luminous paints are often made from methyl-methacrylate. The solutions of the resin are neutral and are, therefore, ideal binders for the luminous pigments which are adversely affected by acidity.

Pigmented acrylic film are inclined to be brittle, particularly where pigmentation is high, and are difficult to plasticize because of the incompatibility of the resin with other film forming materials. Developments may overcome such disadvantages.

Polystyrene

Polystyrene is a resin which, to date, has not had very wide acceptance in the protective coatings field. Polystyrene varnishes have been available for several years and have found some use in the insulation field but offer little or no advantage over a phenolic varnish and are more expensive.

Polystyrene solutions in aromatic hydrocarbons have been used as luminous paint vehicles, but are not as good as the acrylics because the polystyrene materials do not have color-retention characteristics.

Polystyrene solutions are high in viscosity and low in solids. They have a tendency to be stringy and to form cobwebs when sprayed. The films are not particularly tough and lack adhesion to metal. Higher molecular weight polymers would produce greater toughness but introduce even greater application problems and still lower solids. However, deposited films have good electrical resistance, good water resistance, and fair resistance to chemicals. The films remain permanently soluble in aromatic and aliphatic hydrocarbons, esters, ketones, etc. They are insoluble in alcohols.

It would appear that the future of polystyrene in the protective coatings industry depends on the ability of the chemist to develop co-polymers that will correct some of the existing deficiencies.

Vinyl Resins

The vinyls have been known to industry for quite a number of years, and their development in the protective coatings field has kept pace with that in plastics. The vinyl resins are water-white, odorless, tasteless, and non-toxic, which make them of unusual interest as coatings for food containers. Vinyl resin solutions have been

used as can linings for millions of beer cans. They have excellent resistance to moisture, acid, alkali, and most other deteriorants. The films are tough and rubbery when properly plasticized. However, they share the disadvantages of most high polymers, namely, low solids and high viscosity with resulting poor build and difficult spraying.

The coating resins are co-polymers of vinyl chloride and vinyl acetate, the latter being used to achieve solubility in organic solvents. As the ratio of chloride to acetate is increased, chemical and water resistance go up. Viscosity also goes up while solids and solubility go down. Vinyl films dry by solvent evaporation, but hang on to the solvent tenaciously, in most cases requiring a substantial bake to effect solvent release.

Recent advances in application technology have gone far toward overcoming the disadvantage of low solids and high viscosity. This new technique involves the use of a finely powdered vinyl resin known as an "organosol." A chemical plasticizer such as di-octyl phthalate, which is a solvent for vinyl resins, is used in connection with other solvents and non-solvents in such a manner that partial solvation occurs at the surface of the resin particle. Since solvation is only partial, a high percentage of solids can be introduced without encountering abnormally high viscosities. Actually, the coating is applied in powdered form from a suspension in organic solvent. As the non-solvent portion of the thinner evaporates, the solvency of the plasticizer increases the degree of solvation to a point where the coating develops enough cohesion to hold it together until it can be subjected to a bake. Baking is done at a temperature sufficiently above the melting point of the resin to effect a complete fusion of the finely divided resin particles to form a continuous film. Using this technique, the solids at application consistency can be raised to 60 percent or more. So far, the application of vinyl organosols has been limited to the coating of textiles where the material is applied by means of a doctor blade and fusion of the organosol is effected by calendering. Where extremely flexible films are desired, permitting a large percentage of plasticizer to be used, it is possible to apply the films to fabrics at 10 percent solids. These plasticizer-solvated films are known as "plastisols."

Facilities for manufacturing vinyl resins have been substantially increased during the war. Raw materials are in plentiful supply. It is expected, therefore, that the price of vinyl resins will be lowered. With new, improved co-polymers appearing and new application techniques being developed, vinyl resins will surely play a greater part in post-war finishes.

Vinylidene Chloride

Vinylidene chloride resins are commercially available under the trade names "Saran" and "Geon." Both of these resins are generally sold as co-polymers of vinylidene chloride with vinyl chloride, acrylonitrile, and others. Vinylidene chloride resins are first cousins to the vinyls, containing an extra chlorine atom in the molecule replacing one of the hydrogen atoms.

Like the vinyls, the vinylidene chloride polymers are quite insoluble in most organic solvents and require strong ketones to effect solution. They are even higher in viscosity and lower in solids than the vinyls which make them more difficult to apply. The extra chlorine atom in the molecule renders the film less resistant to discoloration in sunlight. However, the resins are extremely resistant to water and chemicals, even surpassing the vinyls in this respect in some instances. Contact with iron during baking causes them to turn black. (This is also true of the vinyls.) Certain stabilizers overcome this to some extent but it is desirable to apply them over a primer where application on iron or steel is involved.

It is the opinion of the writer that vinylidene chloride resins will not be widely used as protective coatings in the immediate post-war era. However, as their solubility and adhesion characteristics, as well as their color retention, are improved the vinylidenes should prove of considerable interest in fields where chemical resistance is paramount.

Silicone Resins

One of the most interesting developments of the present era is in the field of silicone chemistry. Involving, as the name implies, the compounds of silicon, silicone chemistry offers tremendous possibilities. Silicon is one of the most abundant elements in the earth's crust. Millions of tons of practically pure silicon dioxide are available merely by gathering the sands from our thousands of miles of ocean beaches.

Chemically, silicon is analogous to carbon. Both have four valence bonds and form many similar chemical compounds, although these compounds are very dissimilar physically. Organic chemistry is the science of the compounds of carbon. Carbon reacts willingly with hydrogen, oxygen, nitrogen, sulphur, chlorine, bromine, iodine, and many others to form untold thousands of complex organic compounds.

Theoretically, silicon should do the same, but it does not condescend to act so obligingly. However, chemists have found that by employing certain complex organo-metallic compounds such as magnesium methyl bromide, silicon can be induced to keep company with strangers. Compounds have been prepared with most unusual properties. For example, resins have been prepared with grease-like properties to lubricate stop-cocks in chemical glassware. They are extremely resistant to chemicals and will pass through a tremendous range of temperatures with very little change in viscosity.

Another form has been produced which looks and feels like regular putty. Rolled into a ball and placed on a flat surface it will, within a few minutes, flow out to a round, flat disk. However, this same ball, dropped on the floor, will bounce to the ceiling. No one seems to be sure just how this "bouncing putty" may be used to best advantage, but it certainly provides a unique combination of physical properties.

Heat Resistant

One of the most interesting properties of the silicone resins is their extreme resistance to heat. Having also a high degree of electrical resistance, this happy combination makes them ideally suited as electrical insulating varnishes. Overloaded motors do not fail due to insulation breakdown where silicone resins are used. Likewise, smaller, high-powered motors may be built because silicone insulation permits them to be operated continuously at a higher peak load.

In the field of protective coatings silicone resins are just beginning to make their bow. Here, too, heat resistance is the outstanding virtue, making them a natural for stove finishes. Panels have been baked at 600 deg. F. for days on end with little or no color change taking place. The resins are low in viscosity and are soluble in aliphatic hydrocarbons. Enamels spray freely at 60 percent solids. Chemical resistance is excellent, and present indications are that durability is likewise. Although silicon is reluctant to make friends, it is also reluctant to break friendships. Silicon compounds are extremely stable and resist sun, wind and rain.

Present drawback is extremely high cost, for although raw materials are cheap, manufacturing is complicated, dangerous, and expensive. Presumably, as in most other cases, manufacturing experience will indicate simpler and cheaper processes and prices can be expected to drop appreciably. It is a certainty that silicone research will be pursued at top speed for the compounds produced to date have exhibited unusual and unpredictable properties.

Conclusion

It is hoped that the preceding discussion has served to point out that plastics and protective coatings have been, are, and will be one and the same thing from a composition standpoint, and that they differ only in methods of use. The engineer should not be misled by fantastic claims made for plastic paints. They are not a myth, neither are they a cure for all finishing ills. Each type of finish has certain properties that recommend it for use in certain fields. The technicians of the protective coating industry, after study of specific finishing problem, can often help decide what type of finish is best for a specific application. It probably will be a "liquid plastic," but no matter what it is called, it will do the job.

Bearing Design and Installation In High-Speed Superchargers

ZOLA FOX
Mechanical Engineer

Fundamental requirements that must be considered in the design of bearings and methods of lubrication for high-speed superchargers. Advantages and disadvantages of ball, roller and plain bearings are discussed. Types of floating bushings, nut locking devices and thrust collar details are illustrated and described.

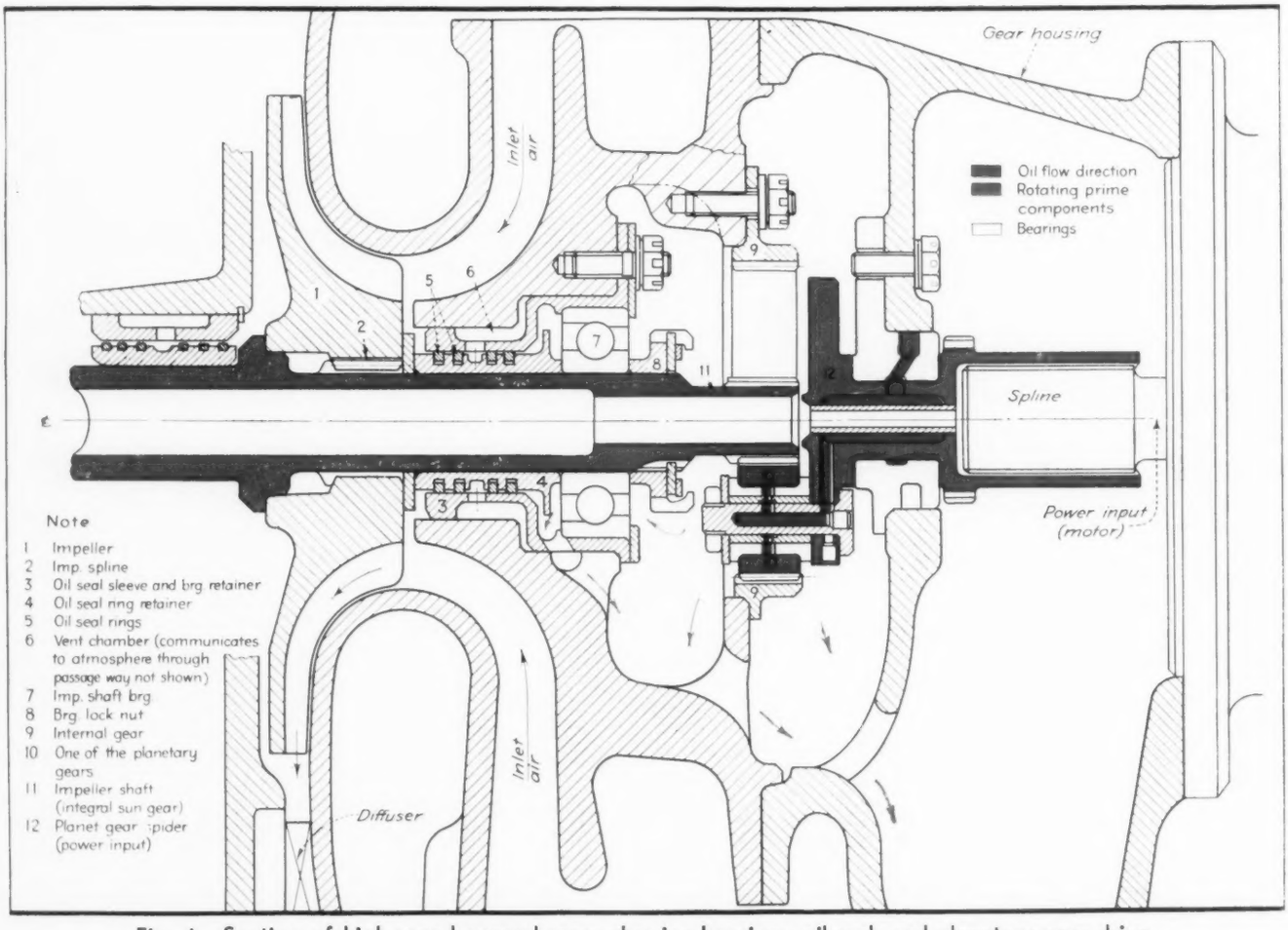


Fig. 1—Section of high-speed supercharger showing bearings, oil seals and planetary gear drive.

SPEEDS exceeding 20,000 r.p.m. are now commonplace. They are no longer considered in the realm of "fancy" design. High speed gas turbines, superchargers, generators, and machine tools are presenting many new problems to engineers. Superchargers of the aircraft type have lightweight, primary components that operate at high rotative speeds, that must function reliably when exposed to extreme temperature, and the stress and strain of combat maneuvers. Most high output superchargers rotate at speeds greater than 25,000 r.p.m., thus making the installation of bearings a specialized problem in high-speed technique.

LOADS ON SUPERCHARGER BEARINGS. In a supercharger mounted in a fixed position in space, and in which the shaft rotates at a constant speed, the bearings must be designed to withstand four loads: The unidirectional radial load imposed by the rotor assembly weight, a rotating radial load caused by forces of unbalance, a radial load resulting from the bearing reactions caused by the gears driving the supercharger (assuming a gear driven supercharger) and a resultant thrust load from the aerodynamic forces on the impeller.

If the axis of the supercharger, while running, is rotated about another axis other than its original axis of rotation, additional loads are placed upon the bearings because

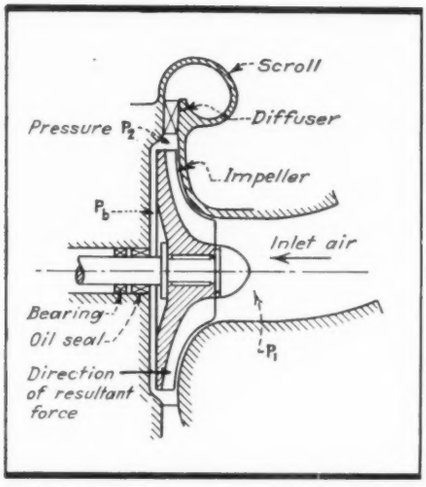


Fig. 2—Direction of resultant force that acts to cause thrust on impeller.

of gyroscopic forces, since the rotor turning at high speed acts as a gyroscope and resists any attempt to move its rotating member into a different plane of rotation.

The bearing load caused by the weight of the impeller shaft assembly is generally negligible, the rotor usually being made of forged aluminum alloy and the steel shaft carefully bored out to reduce weight as much as possible.

Radial loads resulting from gear reaction depend on the transmitted torque and the gear and bearing arrangement. Some designs utilize epicyclic gear trains in which the sun gear is an integral part of the impeller shaft, Fig. 1. The forces between meshing gears that would create shaft bearing reactions if the gear train were not epicyclic, cancel one another out and result in no additional bearing load, at least for an ideal epicyclic gear train that has no machining inaccuracies.

Dynamic balance of an impeller shaft assembly is very critical. Every tear down of a supercharger in which the impeller shaft is disassembled, must call for dynamic rebalancing before final rebuild.

In this article a detailed analytic method will not be given for arriving at an exact value of the thrust on an impeller, but its existence can be explained briefly in a qualitative manner with the aid of Fig. 2. Since the impeller imparts a static pressure rise to the air flowing through it, in the zone between the circumference of the wheel and the diffuser the static pressure P_2 is greater than static pressure P_1 of the inlet air. Since the oil seal prevents, or at least restricts, leakage from the crankcase or gear box back of the impeller, the average pressure P_b in back of the impeller is between P_2 and P_1. Hence because of the difference between pressure P_b and the average pressure acting on the front impeller face, a net resultant force acts on the impeller in the direction of the arrow. An additional force acts on the impeller in the opposite direction because of the axial deceleration of the air entering the supercharger where the direction of airflow is changed from axial to radial in the impeller. This force is equal to WV/g, that is, the change in momentum of the air, where W/g is the mass flow, and V the inlet velocity. The magnitude of this force is less than that resulting from the difference in average static pressure on the front and rear impeller faces.

An empirical rule for estimating the magnitude of the thrust load for aviation type centrifugal superchargers places the thrust load in pounds about equal to the supercharger air horsepower.

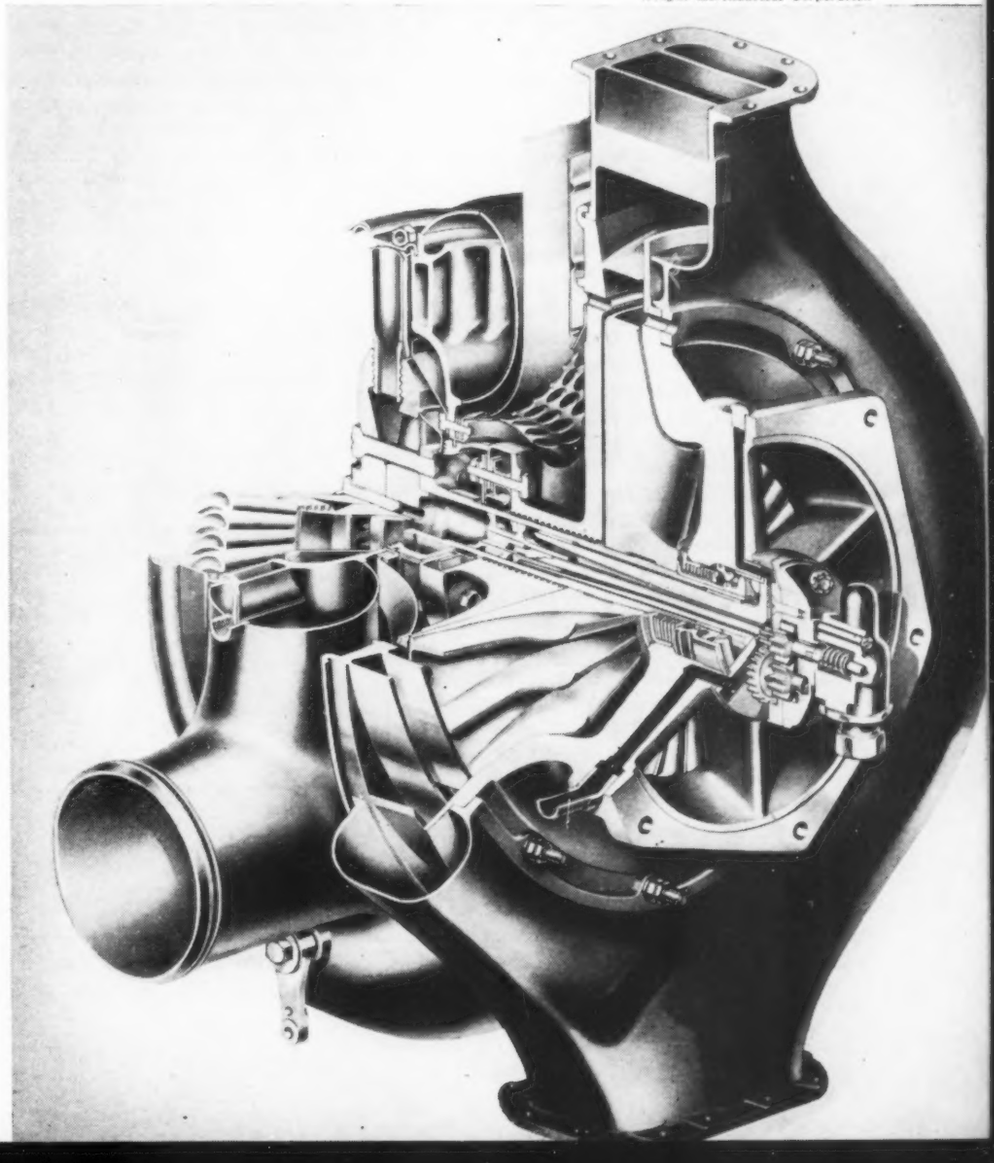
ANTI-FRICTION BEARINGS. Ball bearings are extensively used in superchargers. In addition to taking radial load, in many standard superchargers ball bearings also simultaneously take the entire thrust load. The ball bearings are of the super-precision type, manufactured in accordance with the super-precision specifications of the Annular Bearing Engineers Committee (A.B.E.C.-5), and are equipped with special plastic ball retainers. In the author's experience metallic retainers in ball bearings have never stood up at high speeds. For superchargers, the ball bearings usually have a static diametral clearance of 0.0003 to 0.0007 in. and a maximum axial clearance of about 0.006 in. Both ball and roller bearings with the radial clearance near the upper permissible limit usually run cooler than bearings with little radial play.

Roller bearings are also used extensively in turbo superchargers. They have been tested extensively under high temperatures. Roller bearings also are manufactured to super-precision limits. Permissible diametral clearances are usually 0.0006 to 0.0010 in. Machined metallic retainers, generally brass, separate the rollers.

Under normal operation the loads imposed on both ball and roller bearings by the supercharger are small in comparison with the loads on the outer races caused by the centrifugal forces generated in the balls or rollers. The loading created by the speed of rotation is more likely to cause failure rather than the absolute value of the reactive loads placed upon the bearings. Failure is generally by fatigue of the balls or races.

Fig. 3—Internal structure of the Wright turbo supercharger that is driven by the exhaust gases of an aircraft engine.

Wright Aeronautical Corporation



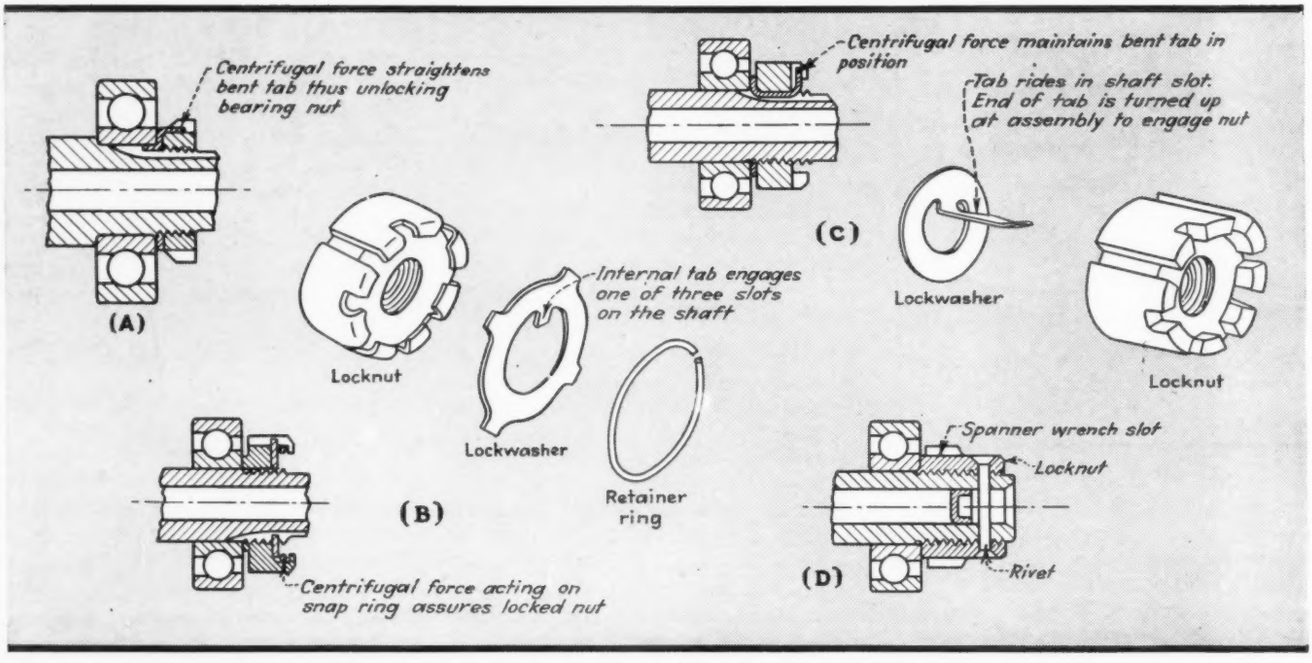


Fig. 4—(A) Type of bearing lock nut in which centrifugal forces may bend open the lock washer tab. (B) Ranger type locknut in which centrifugal force increases the locking action of the snap ring. (C) Rolls Royce lock nut in which centrifugal force assists in maintaining the bent tab in position. (D) Riveted lock nut increases the work of disassembly and assembly operations.

This observation, incidentally, also holds true in high speed gearing.

ANTI-FRICTION BEARING MOUNTING. To assure proper functioning, careful design of the installation and lubrication of supercharger ball and roller bearings are required. An ordinary bearing lock nut, Fig. 4 (*A*), is not suitable for high speeds as the centrifugal forces may bend open the tab of the lock washer and hence unlock the nut. The Ranger type of locknut, Fig. 4 (*B*), not only has the same feature of multiplicity of locking positions as the standard bearing nut, but in addition, centrifugal force helps make the locking action of the snap ring even more positive. The Rolls Royce lock nut, Fig. 4 (*C*), also utilizes centrifugal force to assure locking. Riveting of the lock nut, Fig. 4 (*D*), is common but has the disadvantage that every disassembly calls for a rivet removal operation and every assembly a riveting operation.

Anti-friction bearings on superchargers are a push fit on the shaft and are usually retained in the housing, commonly an aluminum or magnesium casting, by a steel cage. Disassembly of a bearing from its shaft will generally reveal an orange-brown deposit on the contacting surface of the shaft and bearing. The bearing and shaft are then said to have "fretted" or "galled." This deposit is a result of combined corrosion and wear and is caused by a very small motion of the bearing inner race relative to the shaft. Minute relative motion of two surfaces contacting one another under high pressure creates sufficient heat locally to cause fusion and welding, followed by tearing of the weld as the surfaces move apart again. Oxidation of the torn weld material creates the orange brown deposit. "Fretting" or "galling" of the bearing on the shaft can never be completely eliminated, but a close push fit of the bearing on the shaft is said to have some beneficial effect in reducing "galling."

ANTI-FRICTION BEARING LUBRICATION. Until recently engineers were of the opinion that ball and roller bearings were best lubricated by a mist or spray of oil. A mist generated by a gear or nut splashing in oil results in a small quantity of oil being delivered to the bearing and hence prevents over-heating and power loss caused by churning of excess oil.

Mist or spray lubrication is effective for ordinary supercharger installation, that is,

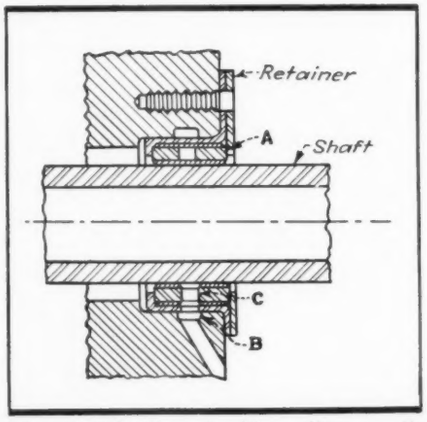


Fig. 5—Floating bushing slips on its outer diameter.

for speeds up to about 28,000 r.p.m. At higher speeds, especially when bearings are subjected to external sources of heat, lubrication by means of a jet directing a relatively large quantity of oil either at the outer race or at the roller or ball retainer has shown considerable improvement on bearing life, especially on roller bearings. The heat generated by the bearing, and the heat generated by the churning of the oil is dissipated by the large oil flow. Rapid and efficient removal of the lubricating oil from the vicinity of the bearing is also important and means for accomplishing this effectively must be considered in a new design.

PLAIN BEARINGS. Although ball and roller bearings in superchargers are extensively used here and abroad, plain journal bearings and thrust collars are meeting with increasing favor. When properly designed, plain sleeve bearings and thrust collars are more satisfactory than "anti-friction" bearings. Greater reliability, freedom of service, long life, and ease of inspection and replacement can be had by correctly designed plain bearings at the expense of an increased power consumption and oil flow.

Plain bearings and thrust collars have higher coefficients of friction and require more oil than ball or roller bearings, thus complicate oil sealing because of the larger quantities of oil needed. Plain bearings are generally made of lead bronze (A.M.S. 4842), some are of the indium diffused lead plated type. Lead bronze is desirable for a bearing because it retains its strength at high temperatures and has desirable run-in and self lubricating properties. Diffused

indium plating imparts to lead bearings improved resistance to corrosive lubricating oils and increases the wearing qualities of the bearing.

Static diametral clearances in plain bearings are generally between 0.002 and 0.004 in. for shaft diameters of about 1 1/2 in. Any specifications that require a given minimum oil flow or oil temperature rise for a particular supercharger may govern the clearance chosen. Decreasing clearance not only has the effect of cutting down the oil flow, but also increases the bearing operating temperature and tendency to seize when overheated, and the higher bearing temperature also reduces the life of the lubricant used.

The importance of concentricity of the bearing bores with the bearing inner and outer diameters can not be overstressed. Alignment of bearings, especially those having small clearances, may be critical.

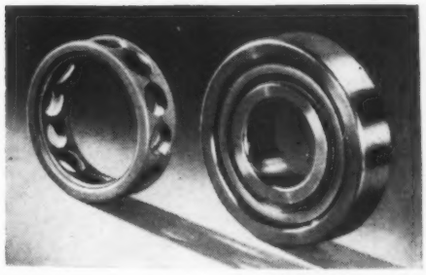
Manufacturers of some superchargers have sacrificed interchangeability of housings in order to have impeller shaft bearings bored simultaneously at assembly. Each set of housings that make up a single supercharger are given the same identification number after being line bored. They are then assembled in the same supercharger in the final build up. Justification for line boring at assembly is immediately apparent, when it is considered that a typical two stage centrifugal supercharger may consist of a pile up of three or more housings that pilot in one another for bearing alignment, and also when thought is given to the necessity for assembly clearances, manufacturing tolerances, and tolerances on concentricities of bearings and housing pilots.

The design of the bearings should allow for adequate strength and cooling. Oil grooves are seldom used, the oil being admitted through an oil hole in the plane of minimum bearing pressure. Shafts are usually made of a carburizing grade of steel such as A.M.S. 6250 and are carburized to a hardness of 58 Rockwell "C" minimum at the bearing journal. A finish having a roughness within 13 microinches r.m.s. is usually called for on the shaft journals.

"Floating" bushings, Fig. 5, are used in several superchargers. This type of bearing consists of a freely floating bushing (A) made of hardened steel and lead indium plated on both inner and outer diameters. It is held by a hardened steel retainer fastened to the housing of the supercharger. Clearance is provided on both the inner and outer diameters of the bushing. In operation the bushing slips on its outer diameter, thereby reducing the linear rubbing speed of the bearing on the shaft. Oil under pressure, introduced at (B), lubricates both the inner and outer diameters of the floating bearing. Generously proportioned radial holes (C) pass lubricant to the shaft rubbing surfaces from the annulus where the oil enters.

Thrust bearings of relatively high capacity have been demanded by supercharger engineers as a result of the development of high speed axial flow blowers, which have high thrust loads. Ball bearings are unsuitable for taking large thrust loads while simultaneously being subjected to high speeds. Two thrust bearings of the collar type that are suitable for high speeds are the Kingsbury tilting block type and the fixed tapered land Michell type of thrust washer.

The Kingsbury type bearing has segmental blocks pivoted on fixed hardened steel buttons in a manner such that the blocks adjust themselves to maintain an oil film wedge



Bakelite Corporation

Fig. 7—Ball bearings mounted in laminated plastic retainers operate at speeds of 30,000 r.p.m., and also at extreme temperatures ranging from 350 deg. F. above to 60 deg. F. below zero.

with the thrust collar on the shaft. The fixed tapered land bearing has a bronze washer with several tapered lands machined on one face so that, through a fixed range of rotative speeds and oil viscosities, an oil wedge is maintained between the washer and a thrust collar on the shaft.

To compensate for any run-out on the thrust face, the Kingsbury type is self adjusting in a manner similar to the classical "leveling plates" utilized in steam turbine practice. The tapered land bearing usually is spherically seated. When properly designed, developed and installed, such bearings under normal conditions operate indefinitely with little care and will withstand considerable overload without failure. Lubrication of the thrust collar type of bearing is not generally simple because of the high oil flows required, and that for good performance the oil should have a radial entry to the rubbing surfaces. The power consumption of the thrust washer type bearing is greater than that of ball bearings.

A design of fixed tapered land thrust bearing is shown in Fig. 6. The thrust washer (A), made of a lead bronze alloy, is spherically seated against a hardened steel seat (B) rigidly attached to the housing. Lubricating oil enters radially through the hollow shaft. Tapered lands on the rubbing face of the washer ride against the shaft shoulder. The angle of taper of the land depends upon the particular installation; the factors that govern the selection of angle are bearing temperature, oil viscosity, speed of rotation and loading. Commonly the angle of taper is as small as 25 minutes.

Oil of 1120 grade is generally used on aircraft supercharger installations. This oil has a Saybolt Universal Viscosity of 115 seconds minimum and 125 seconds maximum with a minimum viscosity index of 95. Oil pressures in typical units run about 40 to 50 lb. per sq. in., and oil temperatures about 180 deg. F. Outlet oil temperatures of 210 deg. F. are typical. High-speed gear pumps driven directly by the supercharger shaft through a worm or spur gear set are used in many supercharger installations, especially of the external auxiliary type.

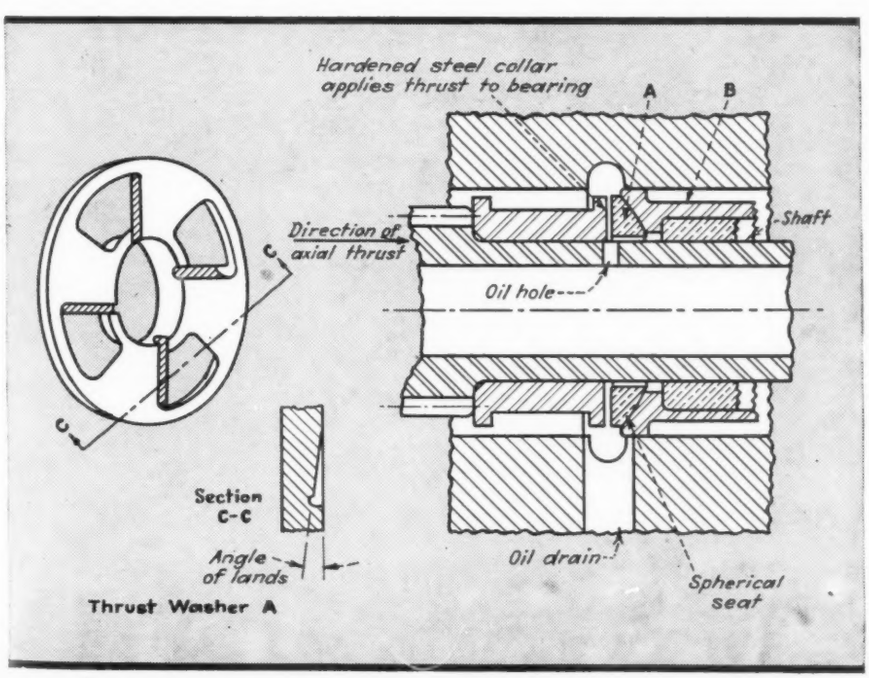


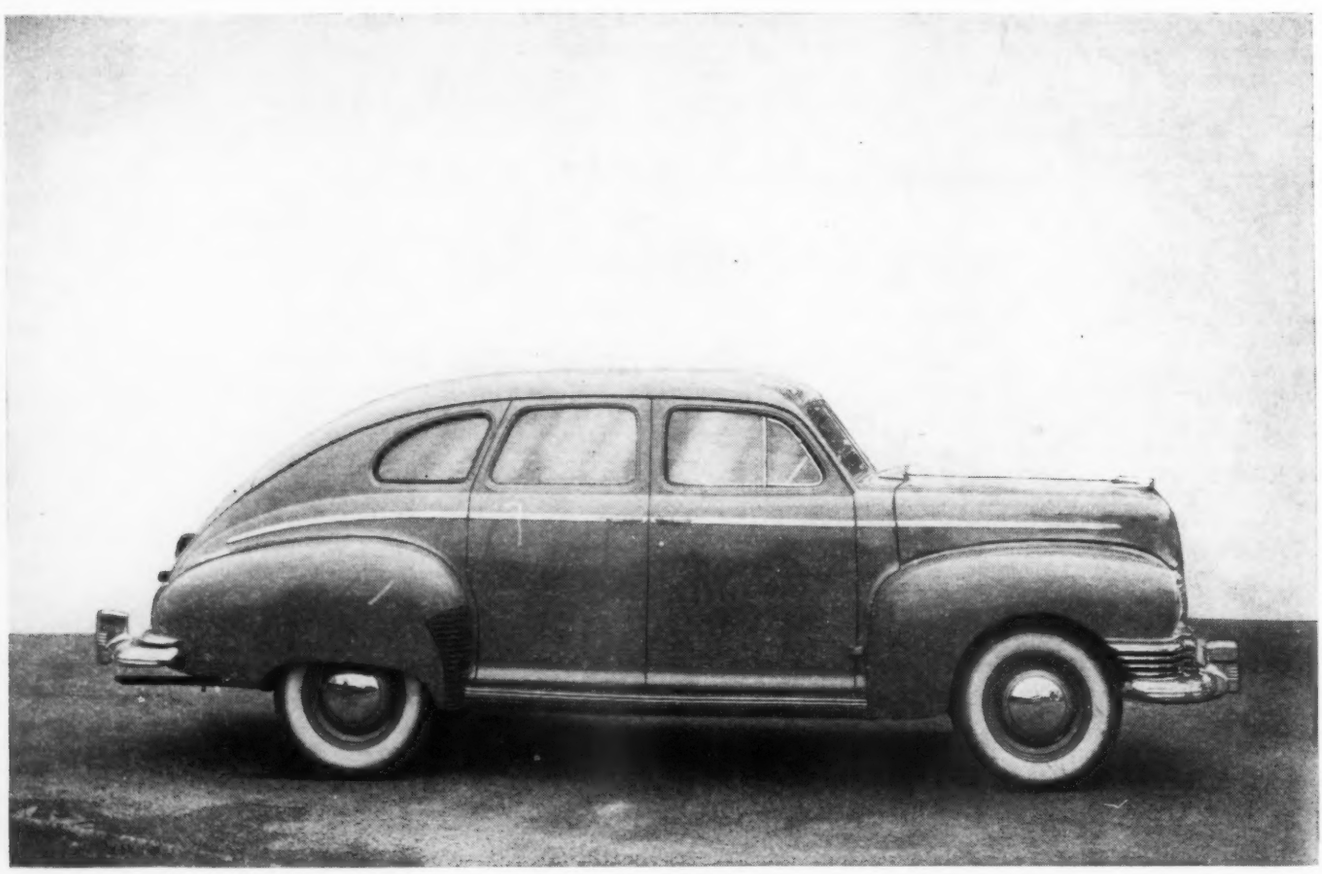
Fig. 6—High-speed thrust bearing with fixed tapered land.

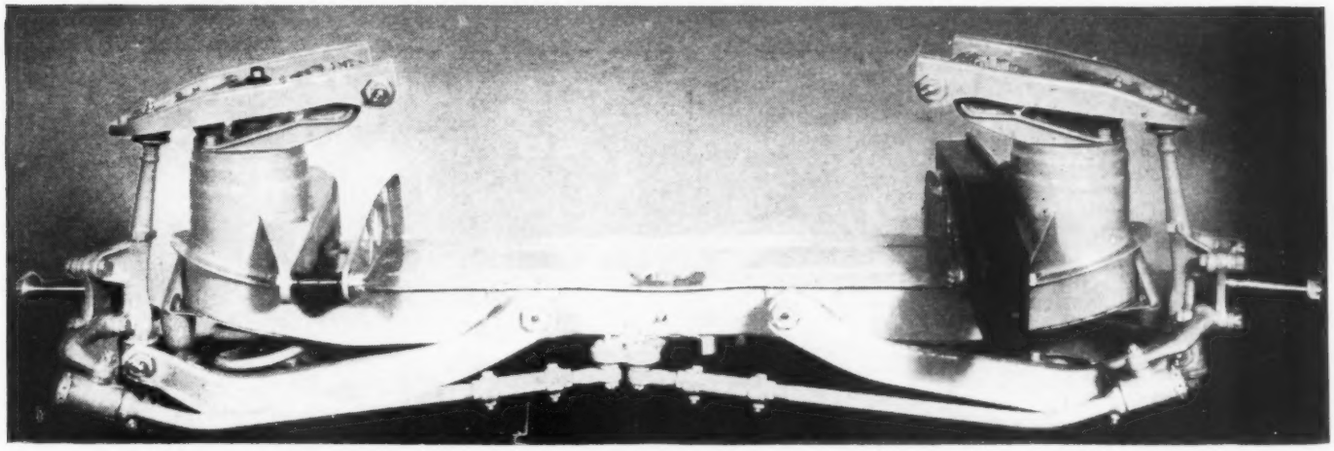
PRODUCT DESIGNS

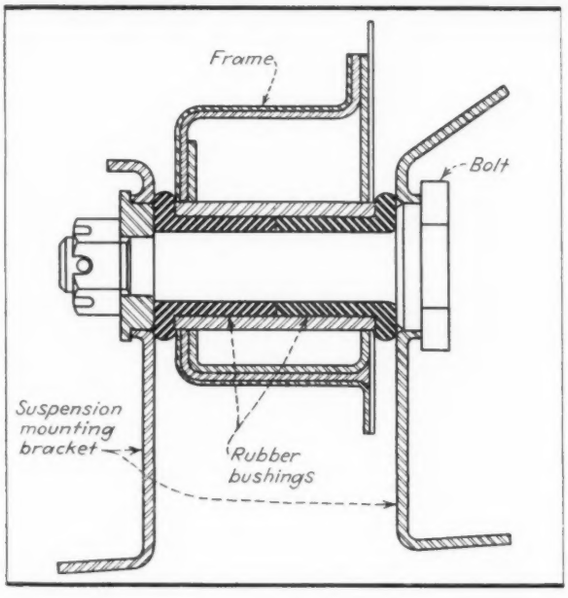
Extensive Design Changes

Mark 1946 Nash 600

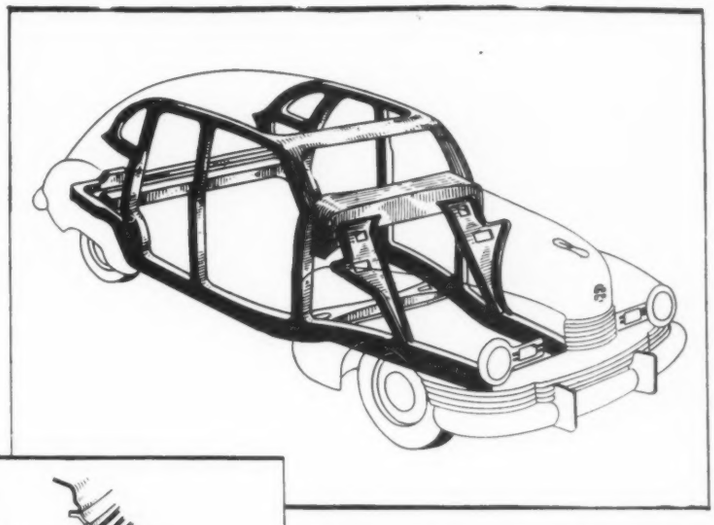
THE 1946 NASH 600 has more new design changes than in the usual yearly model change. Engine has been stepped up in power by detail refinements to develop 82 hp. Appearance has been changed through the use of a heavier chrome belt trim line on the sides of the hood and a molding on the top of the hood. Body has stiffer floors, improved door locks, smoother acting door hinge springs and heavier rear deck lid hinges. Sand-Mortex noise insulation is continued in all bodies. Independent front wheel suspension is of parallel-arm construction. Body and fenders are Bonderized inside and out before painting. Changes have been made in the engine valves, valve springs, intake manifolds, cylinder heads, the lubrication of the piston pins and cylinders, connecting rod bushings, and the cooling of both cylinders and valve seats. New oil seal and drain prevents oil from working into the rear wheel brake drums. Silencing ability of the muffler has been improved and tail pipe extended to reduce exhaust noise and prevent fumes seeping into the car.



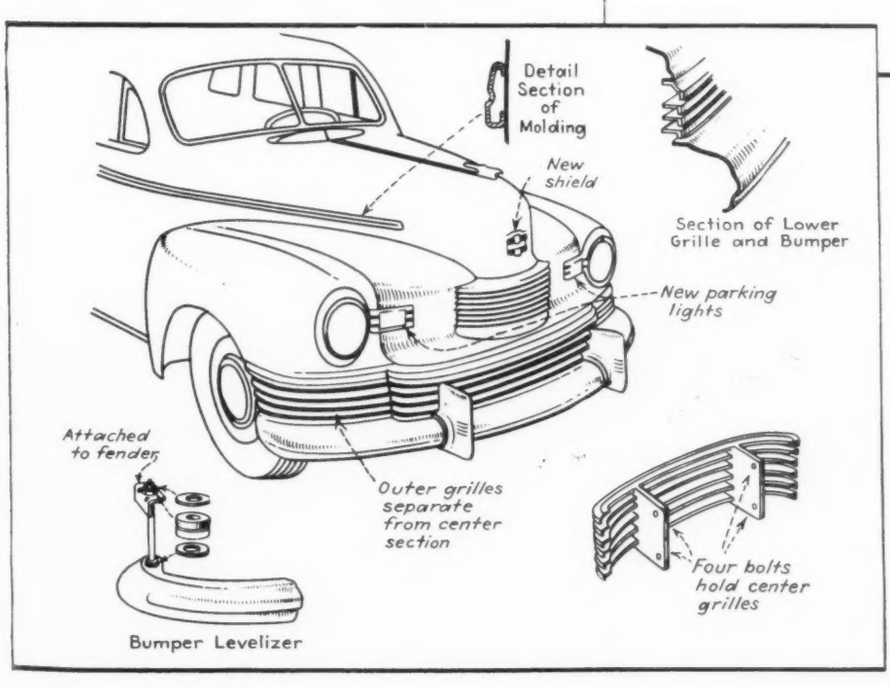




(Above) Front suspension can be removed and replaced should damage occur. Removal requires only the loosening of four bolts. Box-like members form the foundation for this subassembly to which are attached the wheel supporting arms, front coil springs, steering linkage, shock absorbers and front wheels. (Left) Four rubber-encased bolts attach the front suspension sub-assembly to the frame.



Body and frame are of unitized construction. Front and rear suspensions are attached directly to the one-piece bridge-like structure.



Center grille bars are a chrome plated die casting held in place by four bolts. The four lower grille bars are made from stainless steel and built up in three sections. Bumper has a leveling link at each end to permit adjustment of gap between the bumpers and the grille bar.

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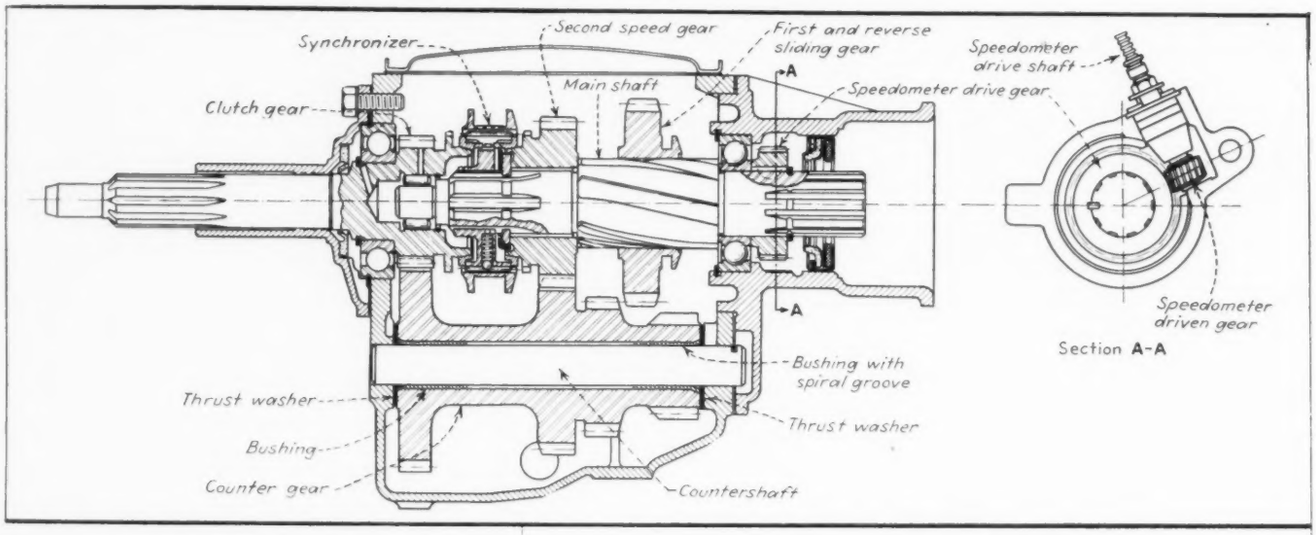
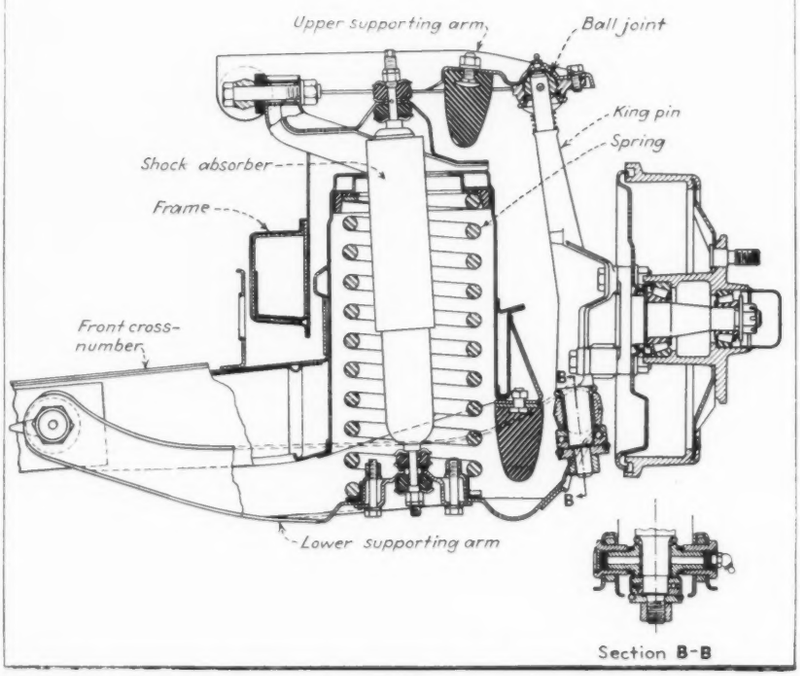
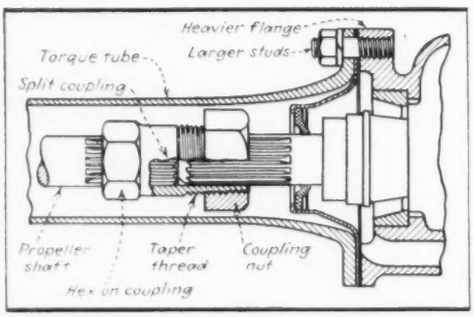
1946 Nash (continued)



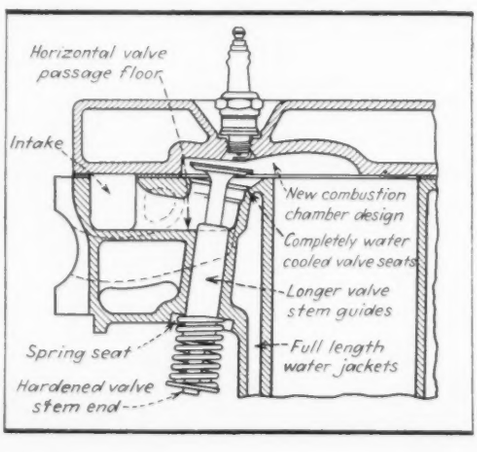
(Above) Transmission has increased capacity. The main and countershaft are increased in size and are located 3 instead of 2 1/2 in. apart. This change decreased bearing and tooth loads. Larger diameter synchronizers make shifting easier and quieter. Countergear bushings are lubricated by a spiral groove in the rear bushing. This spiral groove acts as a pump forcing oil through the front bushing and thrust washer.

(Right) King pin is between the upper and lower supporting arms to eliminate unsprung weight. Top bearing is a ball joint and the lower bearing is a cross. Bearings are farther apart than in conventional king pin design, and since the bearing load is less, wear is reduced. Direct double-acting shock absorbers are placed inside the springs for better protection.





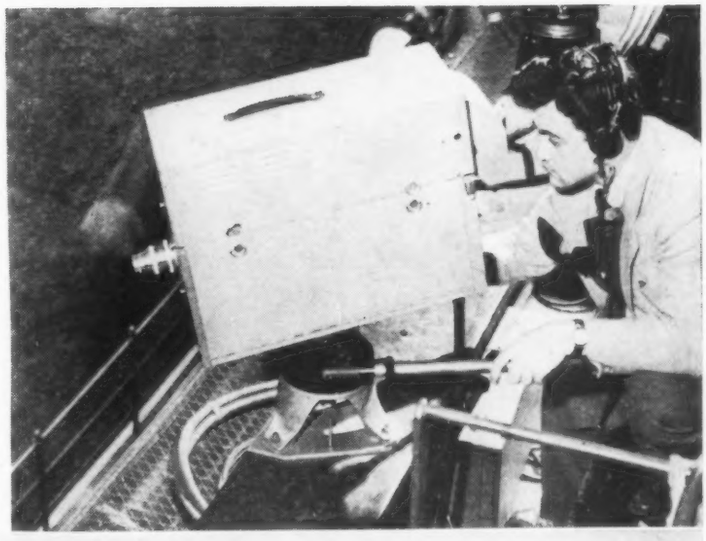
(Above) Drive shaft is connected to the rear axle pinion through a split coupling having a tapered thread and hexagonal lock nut. A hex is formed on the front end of the coupling so that the propeller shaft can be held from turning while the coupling nut is being tightened. Torque tube flange is heavier and holding studs are increased to 7/16 in. diameter.



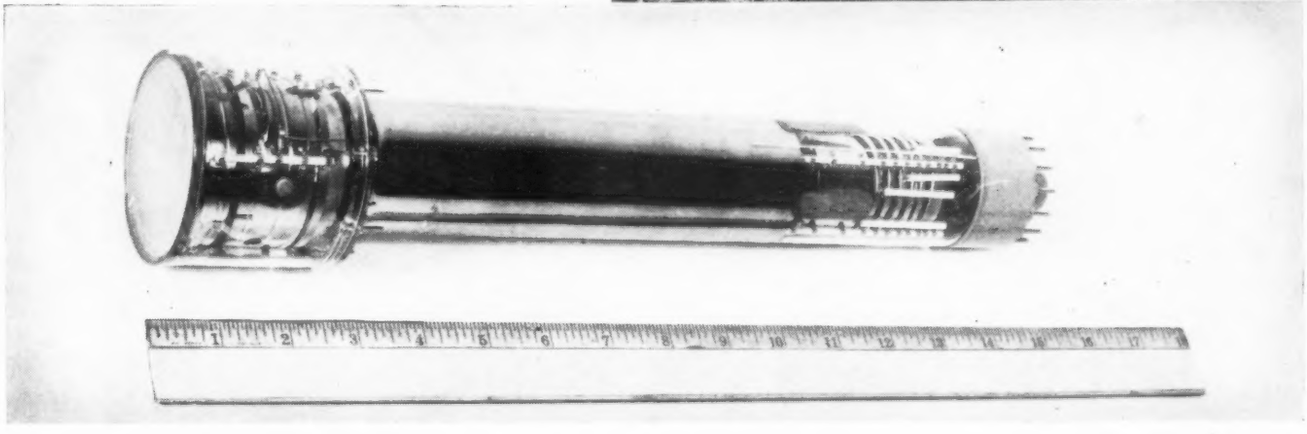
(Left) Intake manifolds and exhaust passages have been modified. Intake floor is now level to prevent fuel being trapped beneath the valves. Intake valves are 1/8 in. larger in diameter. Valve stem guides are longer and better cooling is obtained by circulating water all around the exhaust valve seats.

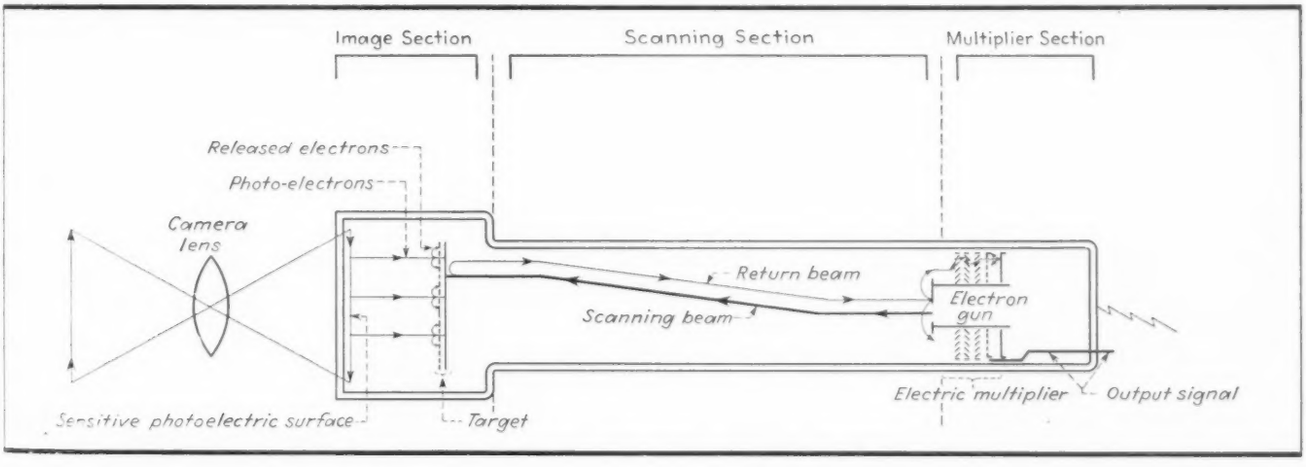
Super-Sensitive Television Camera Design

Simplified, lightweight, portable television camera employs a super-sensitive pickup tube. Designed and developed by the Radio Corporation of America the new camera is expected to revolutionize television programs. Camera will televise scenes and events, either indoors or outside, under extremely low light conditions, where pickup with other cameras has been impossible. Camera will respond, without readjustment or loss of detail to a greatly increased range of light intensities.

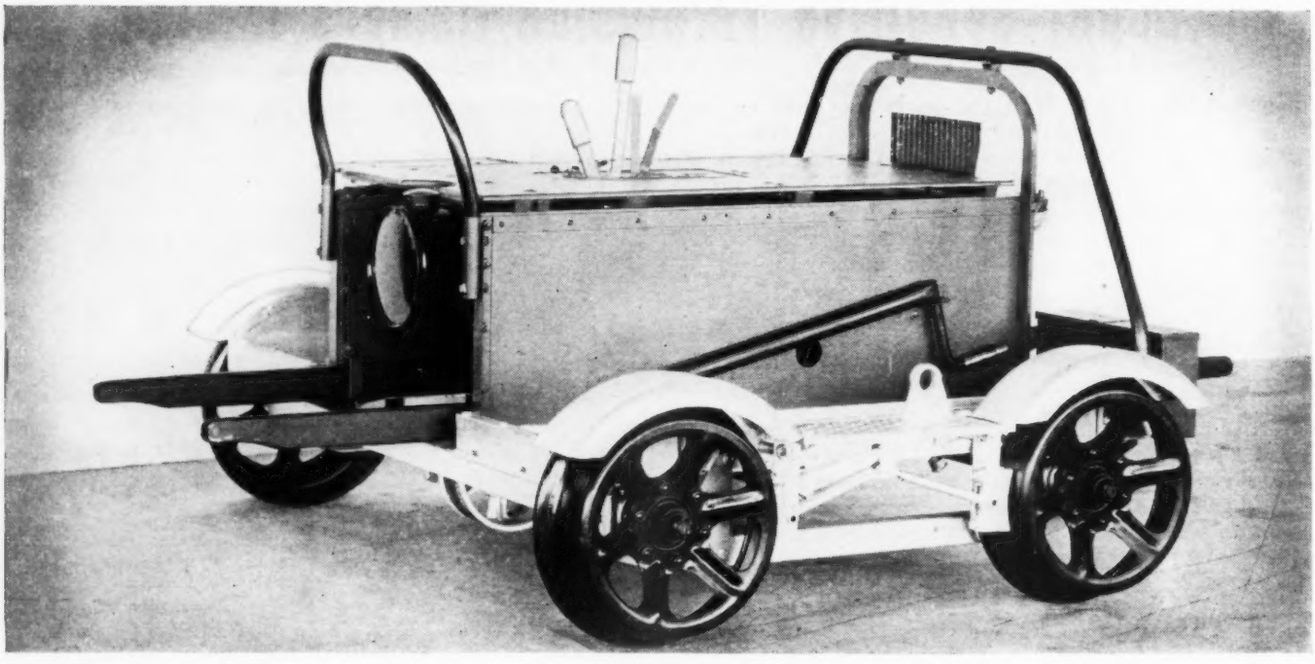


Heart of the camera is the RCA Image Orthicon tube. Overall length of the tube is about 15 in., with the shank diameter 2 in. and head has a 3 in. length and 3 in. diameter. Tube has three main parts: an electron image section; an improved Orthicon-type scanning section; and an electron multiplier section.



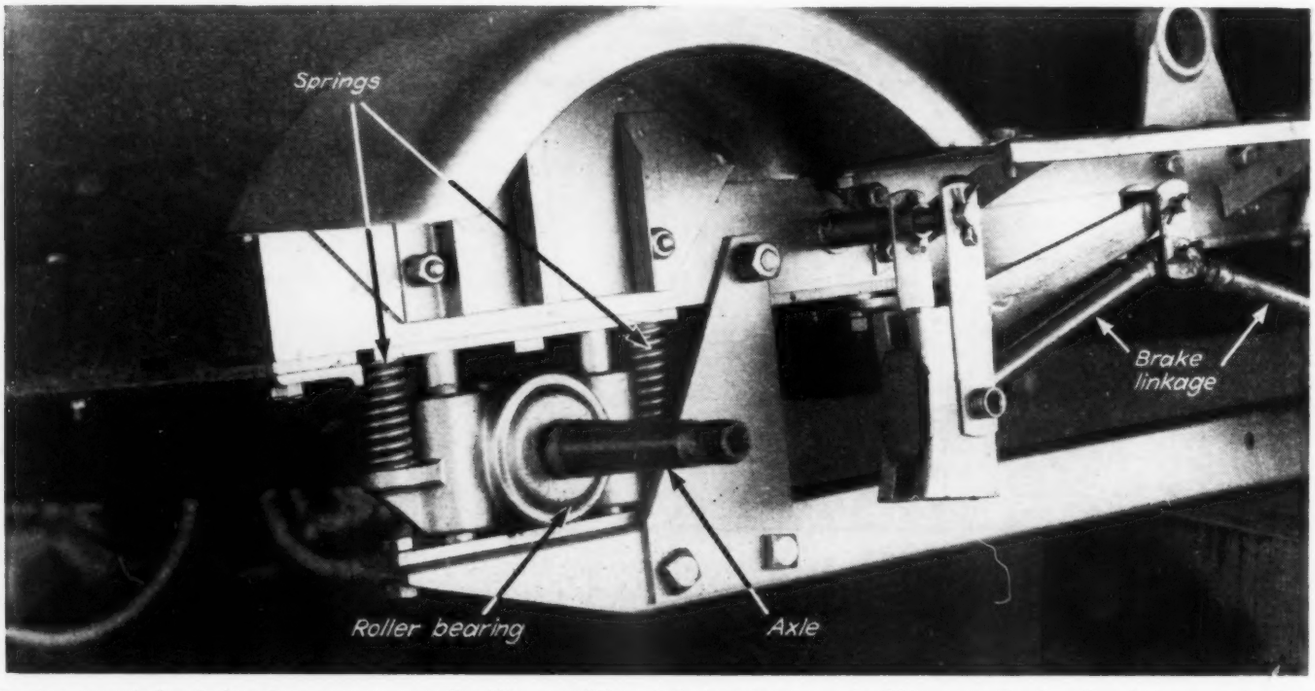


Light image from the subject is picked up by the camera lens and focused on the light-sensitive face of the tube, releasing electrons from each of thousands of tiny cells in proportion to the intensity of light striking it. These electrons are directed on parallel courses from the back of the tube face to the target, from which each striking electron liberates several more, leaving a pattern of proportionate positive charges on the front of the target. When the back of the target is scanned by the beam from the electron gun enough electrons are deposited at each point to neutralize the positive charges. Remainder of beam returns to a series of electron multiplier stages or dynodes. Thus, the signal beam is multiplied many times and carried out the tube to the television broadcast transmitter.

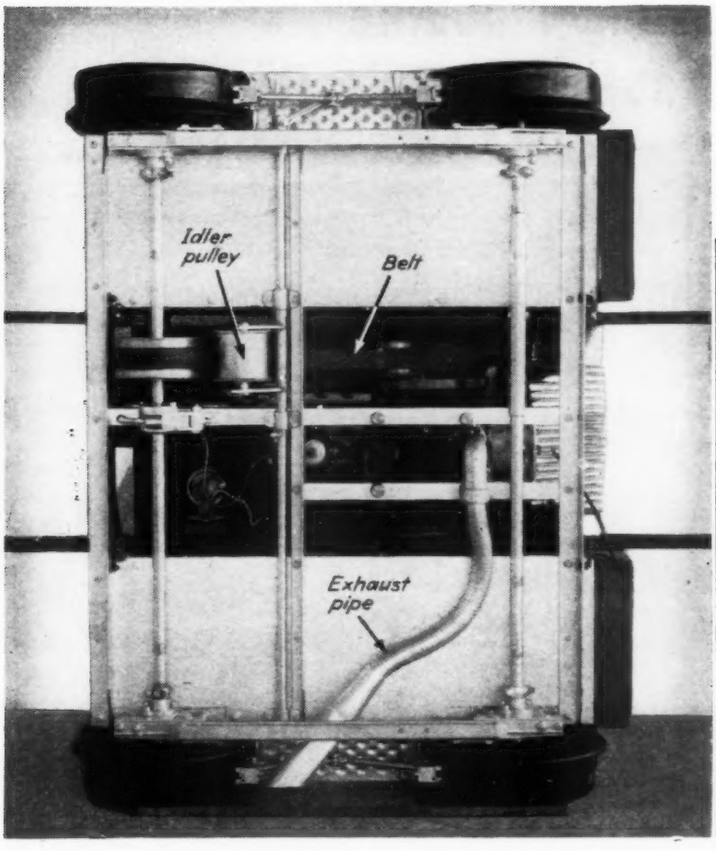


Lightweight Railroad Inspection Car

DEAD WEIGHT has been eliminated from a railroad inspection car through the use of Plymetl and Phemaloid panels and an aluminum alloy frame. Manufactured by Fairmont Railway Motors Incorporated the car can be set off or re-railed by one man. Haskelite Plymetl, a combination of metal and plywood, is used for the tool floors located on either side of the car and maintains the squareness of the frame by acting as gusset plates. Haskelite Phemaloid, a heavy duty plywood, is used for the seat. Handles are designed to pull out from either end and with handles extended rear lift is 98 pounds.

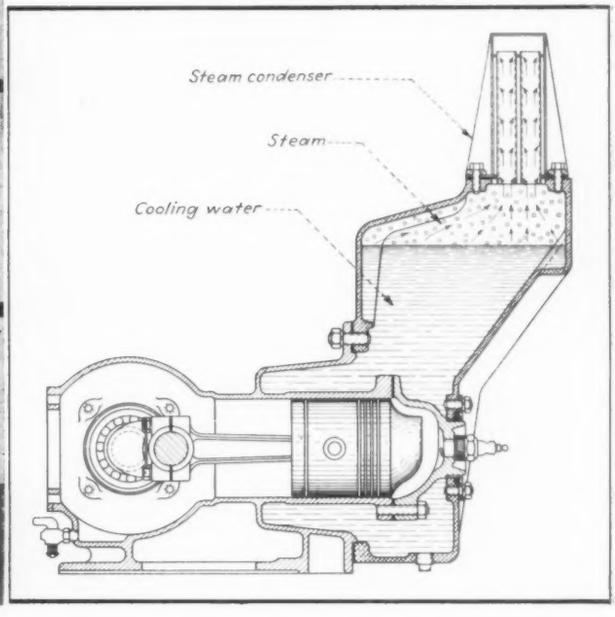


Spring mounted axle bearings assure smooth riding qualities. **Axle** bearings are double-row tapered roller bearings. Brakes operate through a toggle linkage. Construction allows easy servicing and maintenance.



(Left) **Belt drive** is simple and has an idler pulley to control belt tension. Exhaust is carried to the side of the car through a flexible exhaust pipe.

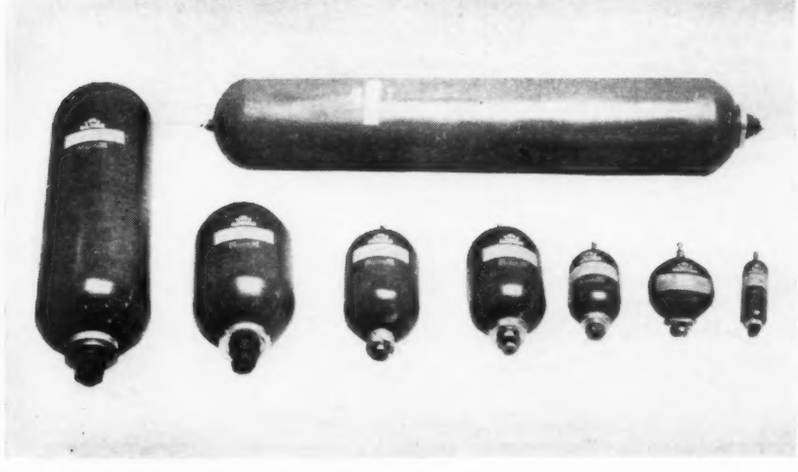
(Below) **Power** is supplied by a 5-8 h.p., two cycle, single cylinder Fairmont roller bearing engine. Water cooling is used and a steam condenser conserves the water supply.

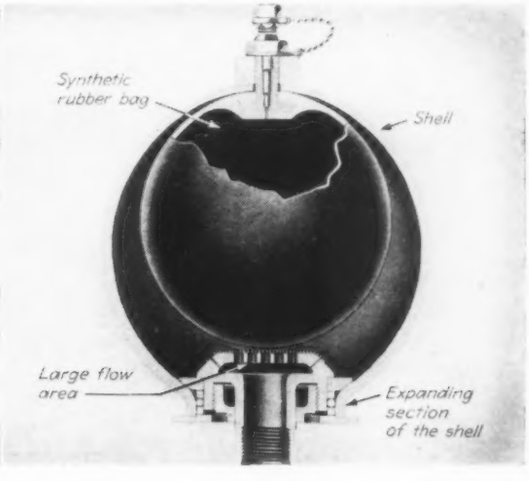


Hydraulic Accumulator Has Burst-proof Design

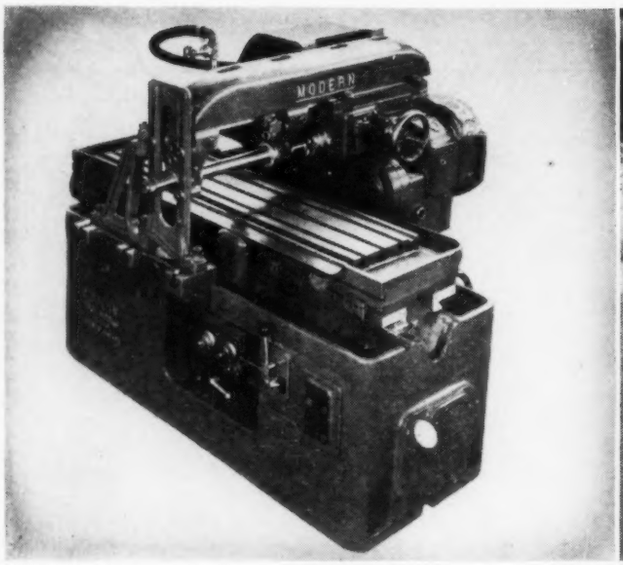
A NEW ACCUMULATOR designed and developed by Greer Hydraulics, Inc. allows the neck of the accumulator to expand and permit oil to leak out without danger of explosion. Available in a wide range of shapes and sizes the accumulators are designed for operation at either 1,500 or 3,000 lb. per sq. in. Accumulator can be disassembled in the field and has a temperature operating range of minus 65 deg. to plus 160 deg. Fahrenheit.

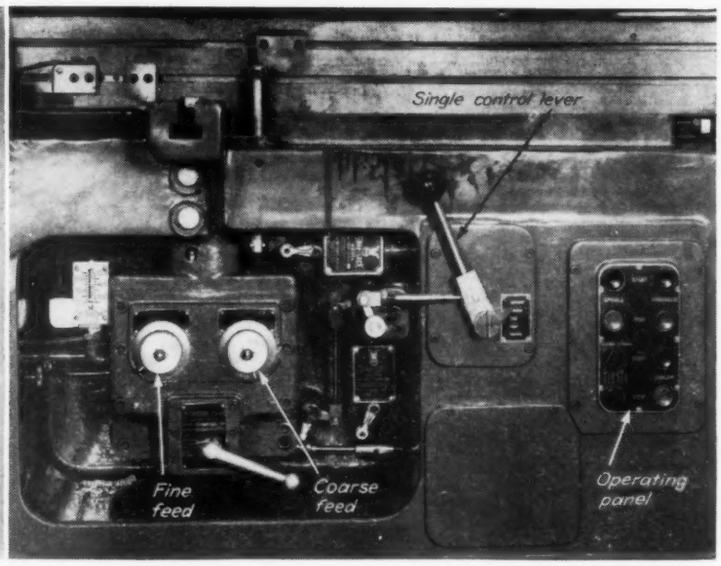
Construction consists of a one-piece shell of uniform thickness having no welds, seams or joints. Air bag is fully inclosed and made of synthetic rubber. Neck of the shell is so designed, that when rated pressure reaches 300 percent of the rated working pressure the neck of the shell expands and oil leaks out. Design of the accumulator neck will not allow disassembly until the air is released. Large flow area gives a low pressure drop.





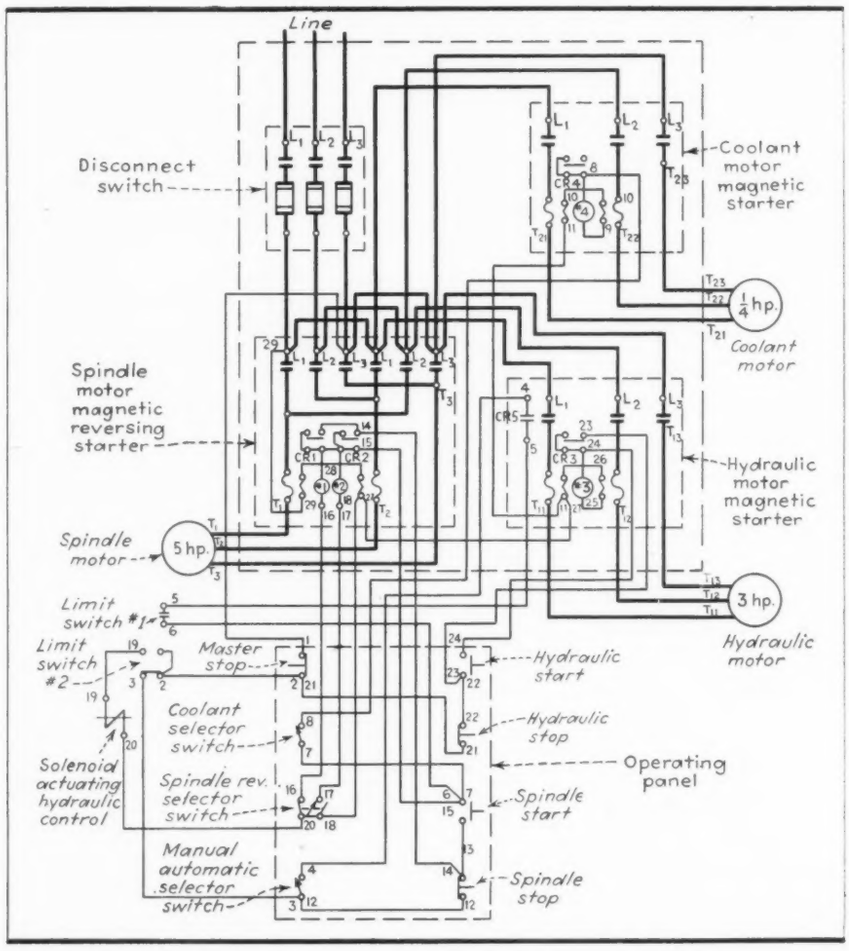
Canadian Milling Machine Has Interlocked Hydraulic Electric Control



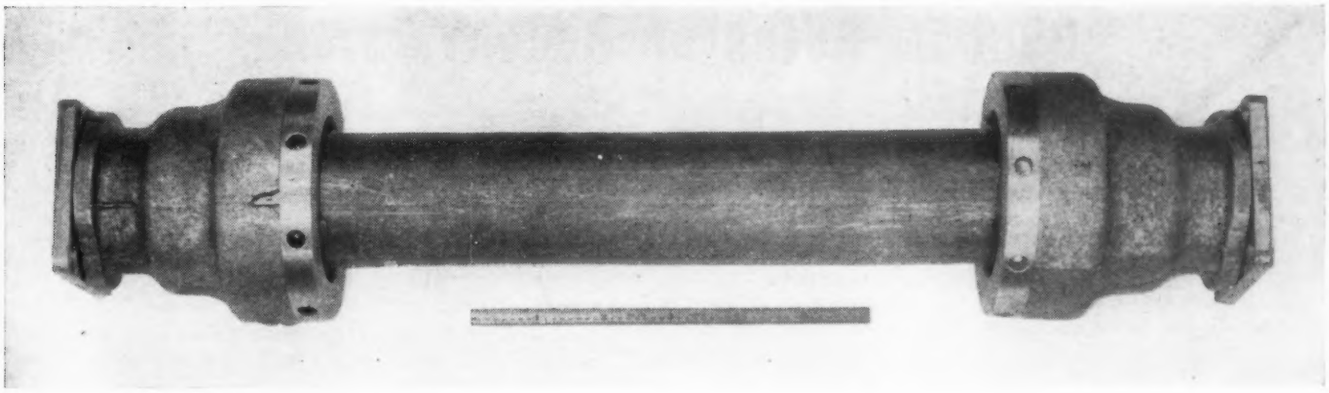


(Above) Designed for heavy cuts this production milling machine has an interlocked hydraulic electric feed control arranged for single lever operation. Developed by Modern Tool Works, Ltd. the machine has a rigid cast iron bed, four bearing spindle support, and automatic-repetition and working cycles. A Vickers infinitely variable dual-feed-rate hydraulic control panel permits quick adjustment of the best operating feed. Gears are of nickel chrome steel and are shaved and induction hardened. Motor starting and reversing switches are grouped into one panel at the operating position.

Hydraulic feed control has two dials. Fine feed dial gives table feed rates from 0 to 8 in. per min. Coarse feed dial gives feed rates from 6 to 40 in. per min. Rapid traverse of 240 in. per min. is a constant fixed rate.

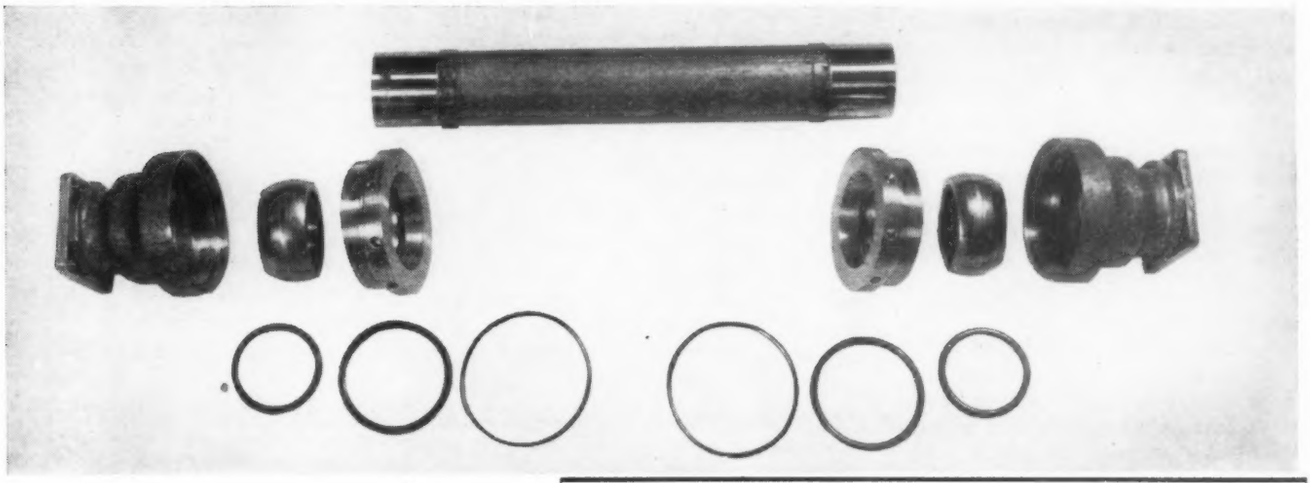


(Right) Electrical control panel is so arranged that spindle rotation or start and stop can be interlocked and synchronized with table movement. Spindle and coolant flow can be started with feed advance and stopped on completion of the cycle.

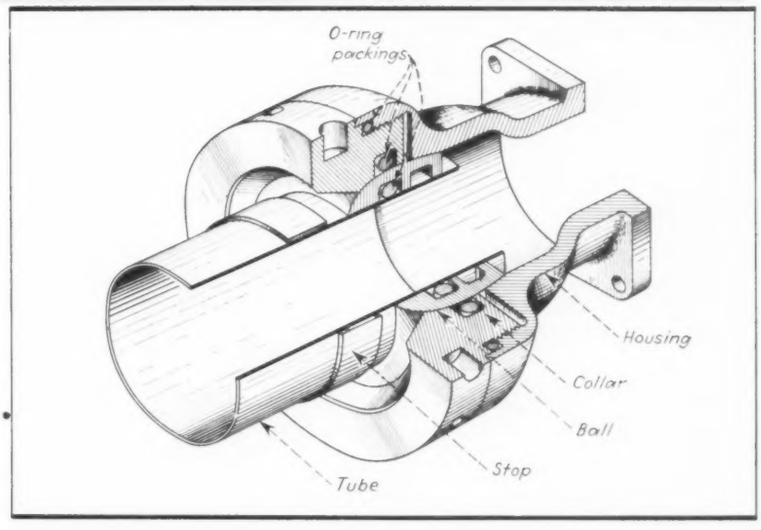


Flexible Fluid Coupling Uses O-Ring Packings

FLEXIBLE COUPLINGS for fluid lines installed between a flexibly mounted aircraft engine and its supporting structure have been a troublesome design problem. Engineers of the Lockheed Aircraft Corporation have found a solution to this problem through the development of a mechanical flexible coupling using O-ring packings. As reported by Harold J. Varhanik, the coupling was tested with a static pressure of 1,000 lb. per sq. in. and a vacuum of 25 in. of mercury with engine lubricating oil at 165 deg. F. and no leaks or failures occurred. Test was made on a vibration fixture with one end of the coupling fixed and the other end mounted on a flywheel. Vibration during this test consisted of rotating one end of the coupling over a circular path of 3/4 in. diameter at a speed of 2,550 r.p.m. with an axial movement of 1/8 in. per revolution.



Coupling consists of a 2 in. diameter tube of corrosion-resistant steel, specification AN-WW-T858, having an 0.049 wall thickness. Tube ends are ground and chromium plated. Ball end is machined from corrosion resistant steel, specification AMS-5461, and the surfaces resting against the housing and tube are finished to 10 RMS microinch. Housing is cast from specification 195-T6 aluminum alloy and collar is machined from 24ST aluminum alloy. Three O-rings are used and O-ring grooves are dimensioned according to standards developed by Lockheed.



Random Notes on Reconversion

Mechanical and styling changes feature the 1946 Chevrolet. Bumper, radiator grille and headlamps present a combined appearance of simplicity. Engine is equipped with lightweight cast alloy iron pistons. Steering linkage is designed to maintain front wheel alignment and eliminate road shock. Gear shift is vacuum powered.

* * *

Fire equipment has been developed for diesel electric locomotives, by the C-O-Two Fire Equipment Company, that turns them into a fire engine on rails. Apparatus automatically detects both smoldering and fast burning fires underneath or inside the locomotive. Oil or brush fires as far as 100 ft. from the train can be extinguished with playpipes.

* * *

Electric roaster ovens announced by the Westinghouse Electric Corporation have outer surfaces finished in white baked enamel. Inner surface, or cooking well, is grey porcelain enamel. Lid is 18 gage polished aluminum and has a glass removable panel. Insulation is layers of fiber glass 3 in. thick on the sides and 4 in. thick on the bottom. Bimetallic temperature control will not cause radio interference.

* * *

Round or square milk bottles are sealed at the rate of 90 per min. in a new machine developed by the Package Machinery Company. Seal is cellophane or parchment, printed in different colors.

* * *

Complete home cleaning system consisting of three units has been announced by the Eureka Vacuum Cleaner Company. First unit is an upright cleaner used for heavy carpeting. Second unit is a tank type cleaner. Third unit is a set of attachments that can be used with either the upright or tank cleaners.

* * *

Cordless electric iron manufactured by the Eureka Vacuum Cleaner Company consists of two parts. Iron contains the heating element and draws current from the base. Base has a cord as well as the thermostat that controls the iron temperature.

* * *

Fluorescent lamp having double the life of previous production has been announced by the Duro Test Corporation. Known as Safreen the new lamp gives a brighter and more mellow light. New lamp will be produced initially only for commercial and industrial users.

* * *

Tomatoes are wrapped and firmly sealed with an over-all cellophane wrap at the rate of 90 trays per minute in a new machine announced by the Package Machinery Company. Method of wrapping permits maximum display but prevents damage to tomatoes by shoppers.

* * *

Electrical wire insulated with natural rubber latex is back on the civilian production list in the wire and cable division of the United States Rubber Company. Smaller diameter of wire is expected to find postwar use where new circuits must be added to existing conduits.

* * *

Automatic machine that produces small-size passenger car tires at the rate of one every two minutes has been announced by the General Tire and Rubber Company. When operated on four six-hour shifts the push-button device can turn out 720, 6.00 by 16, tires in twenty-four hours. This production is five times the average output by the hand-made method.

* * *

Standardization of customers demands for a postwar Water Buffalo amphibious tractor are being sought by the Food Machinery Corporation. The company plans to produce two peacetime models probably with either gasoline or diesel power that will weigh less and carry more than the war models.

* * *

New color printing process reduces the time required, by processes now in use, as much as two-thirds to three-quarters. Announced by the Eastman Kodak Company, prints can be produced with a standard contact printer in less than an hour and a half, excluding negative and print drying time. Successive prints can be turned out at the rate of one every ten minutes. Known as the Kodak die transfer color process it is expected that complete kits will be available early in 1946.

* * *

Compact aircraft brake has been announced by the Firestone Tire and Rubber Company. Brake is described as having a built-in cooling sytem that has reduced excessive temperatures with attendant problems of rapid wear and distortion of brake parts.

* * *

Navigational radar for the Merchant Marine has been announced by Raytheon Manufacturing Company. Called Raytheon Raydar the equipment consists of three units: the antenna, the transmitter-receiver, and the indicator. All three units are designed to permit flexibility in mounting and antenna weight has been reduced to a minimum. Expected maximum range is 15 to 20 miles and the minimum range is 100 yards from the antenna.

* * *

Pen having a small steel ball point is being marketed by the Reynolds Pen Company. Pen is made of aluminum and uses a special ink that won't drip or leak.

* * *

Folding type of baby carriage manufactured by the Thayer Company uses aluminum for all chassis parts except the axles and brake assembly. Weight of the chassis is reduced 25 percent and highly polished aluminum parts improve the carriage appearance.

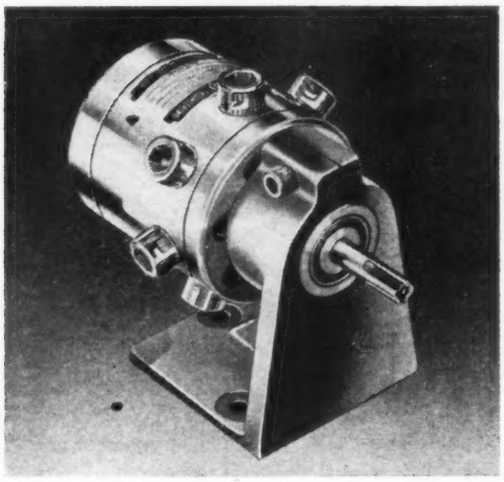
* * *

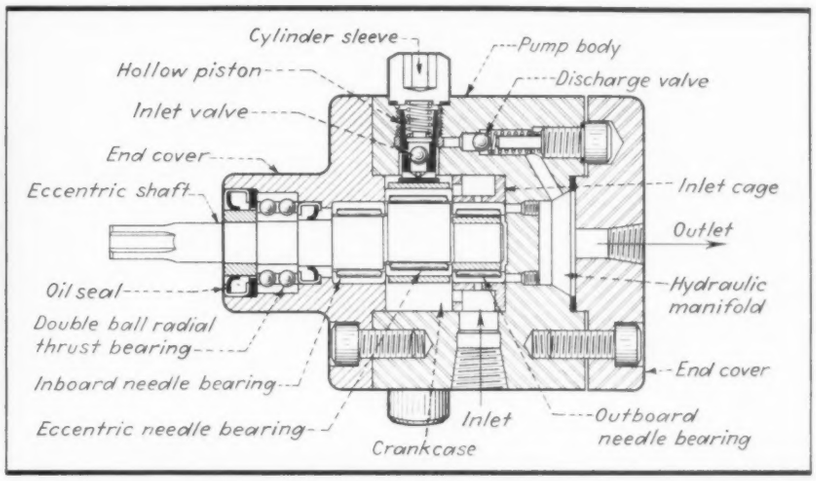
Electric ranges styled with chromium trim and having new engineering developments have been announced by the Westinghouse Electric Corporation. Initial production will be the Champion model, a medium priced range. As production facilities permit the line will be expanded to include models ranging from the large two-oven size to small apartment sizes as well as a combination electric-fuel model for areas where the range is used to furnish room heat as well as cooking.

High-Pressure Radial Hydraulic Pump

HOLLOW PISTON, radial hydraulic pump is capable of producing pressures as high as 10,000 lb. per sq. in. Manufactured by the Simplex Engineering Company the Seco radial pump is not self priming. Pump will operate in either direction of rotation and is of the fixed displacement type. Copper gasket seals are used. Hollow piston, cylinder sleeve, cam follower spring and inlet valve are a subassembly for easy removal and replacement. As fluid builds up pressure inside the hollow piston it expands thus reducing leakage past the piston. Pistons are operated by a needle bearing roller mounted on an eccentric. Eccentric shaft is mounted on two needle bearings and longitudinal thrust is taken by a double row ball bearing mounted in the end plate.

Oil passes through the inlet cage to the crankcase. Hollow piston begins its down stroke opening inlet ball check valve. Piston fills with oil from crankcase until piston reaches the bottom of its stroke. Inlet check valve then closes trapping oil in the piston. As piston moves upward oil is compressed and forced out through the discharge valve to the hydraulic manifold.

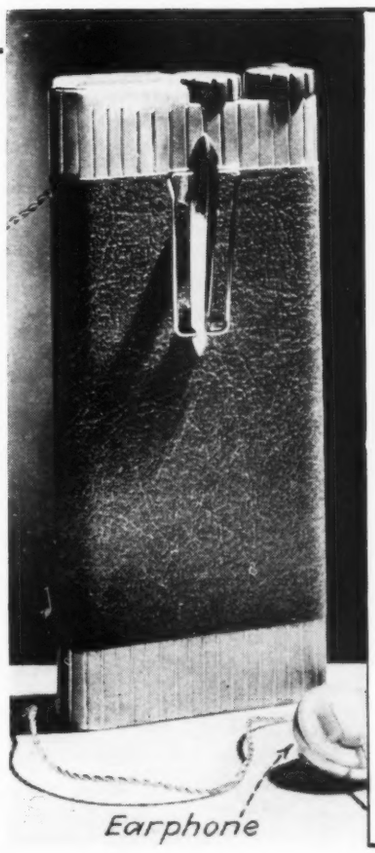


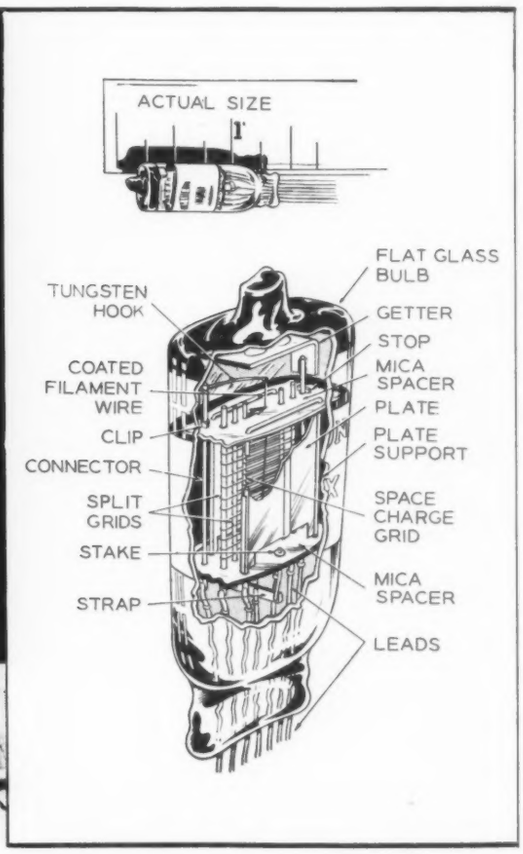


5-Tube Radio Designed to Fit Pocket or Purse

POCKET RADIO receiving set weighs 10 oz., including batteries, and has a 5-tube superhetetrodyne circuit. Manufactured by the Belmont Radio Corporation the radio is 3 in. wide, 3/4 in. thick and 6 1/4 in. high. Compactness of the unit is made possible through the development of sub-miniature tubes by the Raytheon Manufacturing Company. Two of the five tubes are frequency amplifier pentodes, one a triode-heptode frequency converter, one a diode-pentode detector amplifier, and the fifth is an output pentode similar to the type used in hearing aids. Two of the tubes are actually two tubes in one envelope. Set requires only 1/3 of a watt for operation and operates on a 22 1/2 volt B battery.

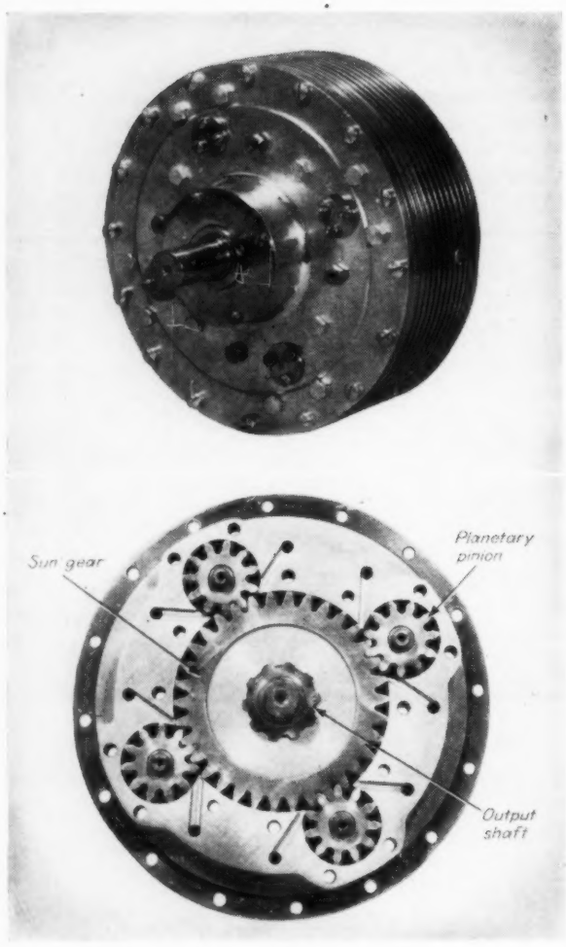
Sub-miniature tube elements are held together at top and bottom by thin pieces of mica. All metal parts are assembled by welding. The filament is made from bare wire less than 0.001 in. diameter.



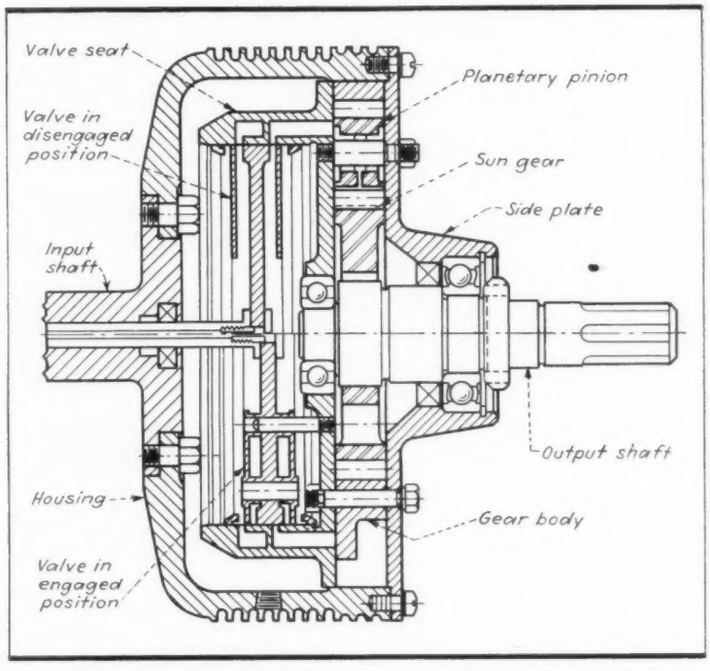


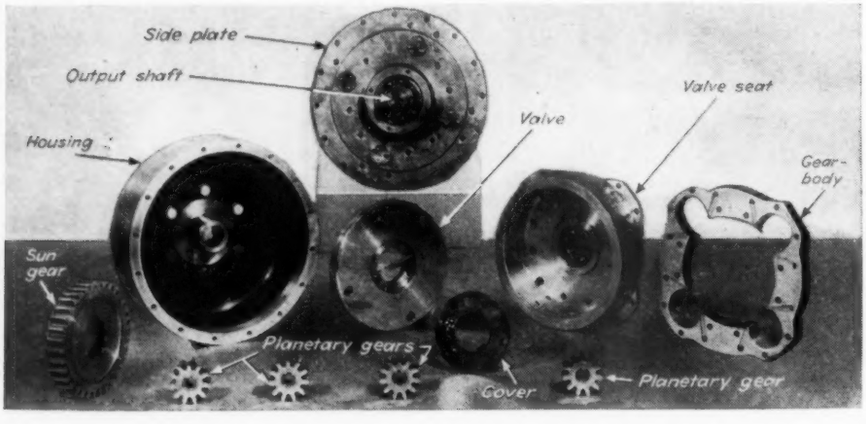
Hydraulic Clutch and Speed Control

TOTALLY INCLOSED HYDRAULIC CLUTCH and speed control, known as the Brad Foote Speed Flo Drive, has been developed by the Brad Foote Gear Works. No standard units are available and each clutch unit is engineered for the particular application to which the unit is to be applied. Clutch unit is basically a hydraulic pump whose discharge and inlet ports can be controlled to create hydrostatic pressure. Shocks are thus cushioned by the hydrostatic pressure. Compactness of the unit allows easy installation on many machine tools, maritime hoists, bus and truck tractors and utility drives. A torque overload device can be included in the clutch unit to automatically control shock or demand loads.



Multiple gear pump unit consists of a sun gear and four planetary pinions. The sun gear is directly attached to the output shaft.





Clutch unit is of compact and simple design and consists of a side plate, gear body, valve seat, valve, housing, sun gear, output shaft, four planetary pinions, cover plate and two ball bearings.

(Above) Rotation of the clutch unit causes the oil contained in the housing to form an anulus of oil with air in the center of the housing. Anulus of oil does not extend to the inside diameter of the valve. When valve is in disengaged position air is drawn through the valve to the pump and discharged back into the center of the housing. As engagement of the valve is started, by an axial movement of the valve, both oil and air enter the pump. **Valve movement** starts to close off the discharge of the pump and creates a hydrostatic pressure against the sun gear. When valve is fully engaged only oil can enter the pump and the discharge ports are fully closed, thus the maximum hydrostatic pressure is acting on the sun gear. By controlling the valve position with a centrifugal governor speed of clutch output shaft can be controlled.

The Cross Roads We Are Facing

IN AMERICA we are riding the crest of a wave of greatness. Of course we are great! Did we not in less than four years build the mightiest Army and Navy the world has even even imagined? Did we not produce weapons in such abundance that we were able to give much to our Allies? The world's greatest scientific achievement of all times, the atomic bomb, is ours! We developed radar, proximity fuses, amphibious tanks, bazookas, and numerous other uncanny weapons! The greatest scientists of the world, refugees from persecution, are now living in the United States! We can rightly be termed a great intellectual nation. It is a situation fraught with danger.

A gruesome chapter of the history of what was once the world's greatest intellectual nation is now being written. Germans could honestly boast of having had the greatest poets, doctors, scientists and humanitarians. Germany was first to adopt workmen's compensation, old age pensions, the kindergarten and free schools. Yet in less than three decades that nation tumbled from its pinnacle of greatness to the shambles it is today, despised and condemned. The cause can be traced to arrogance born of their conviction that, being the most learned people, their's should be the right to rule the world and enslave other peoples.

They forgot the standards by which true greatness is measured. They spurned His teachings; they renounced God. They turned their worship to material things and the gods of ruthlessness.

The people of the United States will not seek world wide empire; our trends are toward isolation. Our immediate danger is internal. Now that exigencies of war are over and we are embarked on a reconversion program, there is a great temptation to rest, relax, take the easy road, or to coast on the accomplishments of the past. Success, individual or collective, has made many feel self satisfied. Perhaps a few feel arrogant. But such an attitude has never created a product that bespeaks, integrity and honesty. To the contrary, such a spirit in the course of its natural growth will destroy the great heritage of industrial leadership that was built by hard work and sacrifice.

Now is a fitting time to take stock not of the accomplishments of the past but of the opportunities of the future. Never before has there been such a wealth of knowledge and material which the designer can use for the creation of ever greater products. Never has there been a more favorable time for contributing so much towards greater prosperity for all. By these tokens, every individual has a great opportunity for building personal prestige. But it cannot be done by resting on laurels, by convictions of greatness or by arrogance born of a sense of superiority. Be it a nation, organization or an individual, such a mental attitude spells disaster in some form or other.

G. F. Zodenkoff

Applied Finishes Standardization And Basic Principles of Procedure

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Principles and practices underlying the selection and establishment of standards for applied finishes to satisfy specific engineering and manufacturing requirements. Two other phases of standardization discussed are: Specifications for procurement, application, and inspection; and publicizing the standards to encourage their use.

THE SECRETARY of Commerce recently called together a group of outstanding industrial leaders to advise him on standards development. This group found that the importance of standards will be ever-increasing. Standards will play an expanding role in the fields of engineering and manufactured products, and ultimately will affect the production and sale of all products. One of the important recommendations made by this group is that executives should make adequate provision for handling of standardization problems, first, within their own companies, and second, within their business associations, and professional and technical societies.

The unique system of material standards and specifications as practiced in the Sperry Gyroscope Company has been described in a recent article ("Materials Standardization", *Mechanical Engineering*, April 1944, page 259). As a sequel to that article, the author here discusses the principles and practices underlying applied finishes standardization at this company.

Applied finishes standardization as practiced at the Sperry Gyroscope Company is divided into three distinct phases: (1) Selection and establishment of finishes to produce the required results, (2) Writing of specifications to cover the procurement, application and inspection of finishes selected, and (3) Publicizing standardized finishes to encourage company wide use.

ORIGIN OF STANDARD FINISH. The need or request for the establishment of a standard finish in this company originates in one of several sources, the most important of which is the product engineer's request for a finish or finishes required on a product that is being engineered for production. The request may be for a new color paint, a new electroplate, or some other surface treatment, called for specifically by the customer or required for the proper functioning of the product.

Standard finishes also result from research work carried on by the company for the development of new and better finishes and improvement of existing ones. A good example is the development of cadmium and copper plating on aluminum recently established as a result of months of experimenting in the company's laboratories. Other finishes, more or less basic in nature, are established for general use on the basis of work done by the manufacturers of these products.

Regardless of the origin, all finishes are carefully tested in the laboratory before promulgation into standard finishes.

Factors Considered When Creating a Standard Finish

Before selecting and standardizing any one process or material for producing a desired finish, careful consideration is given to many factors.

REQUIRED PROPERTIES. The primary requisite of most Sperry finishes is to afford protection against corrosion of the base materials. But the choice of a finish is also dictated by other requirements. In some finishes, appearance in the form of color, sheen, or texture is an important factor. This is especially true of finishes on products designed to have sales appeal. In other finishes, mechanical properties such as hardness, abrasion resistance, adhesion, flexibility, and the like are of prime importance.

Certain finishes must possess properties such as good thermal conductivity, good thermal expansion and contraction characteristics, and resistance to heat and heat aging. Other finishes must be resistant to acids, alkalis, oils, greases, and solvents. Some must exhibit a high electrical conductivity; others a low conductivity. These and an endless number of property requirements may be called for in a finish. One unique Sperry requirement is that paints or lacquers for parts used in optical systems must not fog the lenses. To project all the required properties into any one finish is not always possible. Like other design problems, a compromise must often be made.

PRODUCT REQUIREMENTS. To avoid having too many similar finishes, the finish selected must be satisfactory for use on many of the products manufactured. This often necessitates the adoption of a higher quality and more costly finish than is required for some applications. But experience has shown that this policy results in low overall cost and increased production. For example, red lead primer is satisfactory for use on iron and steel, but it is not as satisfactory as zinc chromate primer when used on light metals such as aluminum and magnesium. To reap the benefits of a single primer system, the Sperry Gyroscope Company has adopted the more costly zinc chromate primer for use on all materials.

CUSTOMERS' REQUIREMENTS. The standardized finish must in general be of a quality entirely satisfactory to the customer. The customer is interested not only in the performance of the complete product, he is also interested in its details of construction, use of materials and finishes. Since many products are sold to government agencies, the finishes selected must be of the same high quality as the ones covered by government specifications.

SERVICE REQUIREMENTS. The finish selected must possess certain inherent properties that are compatible with the service requirements of the product. The applied finish on some of the company's products must resist the low temperatures of the stratosphere and the arctic regions, the high temperatures of the desert, and the corrosive action of salt air and high-humidity climates.

DESIGN LIMITATIONS. Frequently, certain design requirements limit the choice of a finish. For some parts a finish must be used that gives no build-up even though the

finish may possess inferior properties in all other respects. Hardened, ground, and polished pivots, made of chrome carbon steel (SAE 52100), are given a chemical dip black oxidizing treatment that produces no build-up and affords protection against corrosion only slightly better than with no coating. In designs that call for the treatment of two dissimilar metals in an assembly, as in pressed or riveted joints, the finish must treat one metal without injuring the other, and without contaminating baths.

Manufacturing Facilities. Capacity and limitations of shop equipment are also considered. It would be poor practice to standardize on a finish requiring the installation of new equipment when a similar finish is available for which existing plant facilities can be utilized. Why select a finish requiring baking at 450 deg. F. when the ovens in the shop can be heated only to 350 deg. F.? Management will not consent to new capital outlays unless it has been thoroughly convinced that every other alternate has been considered. In certain instances, it may be possible to save equipment and valuable floor space by modifying slightly the proposed finish so that an existing standard proprietary treatment can be used.

Ease of Application. Many pertinent questions need answering when considering this factor. What caliber personnel is required for operation? How much training will the operator require? How much of the operator's time will the operation take, does it require constant attention? How much supervision is needed? Is the process critical as to solutions, temperature, and time that if not controlled may result regularly in quantities of defective work? These and other questions must be thoroughly investigated. The more automatic a process is, the less will these problems be.

Availability. Materials used in the standardized finish must be readily available and in any quantity. Often a superior material or finish is not considered simply because it is produced only by one company.

Cost. In some industries, such as those producing low-priced, highly competitive products in mass production, the cost of the materials and finishes used may be a high percentage of the total cost of the product. In other industries, employing highly skilled labor, it is imperative to standardize on materials and finishes that will produce a low supervisory and direct labor cost rather than a low initial material cost. The initial cost must be further justified in terms of possible service failures that may result in breakdown of expensive equipment, or loss of life and limb.

Number of Pieces to be Treated. Some finishes and processes are economical only for large quantity production; others for small quantity production. In large quantity production, the finish or process selected must be capable of treating parts at the desired rate of output. The question of internal operation versus subcontracting also presents itself. Although the quantity to be treated and cost of installation will be the determining factors, there may be other considerations such as excessive transportation, transportation of delicate parts, and the desire to be able to treat parts within a matter of hours, that may dictate internal installation rather than subcontracting of the finish.

Fire and Health Hazards. Every effort should be made to see that the finish selected does not present any serious fire and health hazards. Here again, it sometimes becomes necessary to set aside a superior finish because of toxicity, irritation, or inflammability. Although ever present in the finishing room, judicious planning at the time of inception of the finish will help in safeguarding against these hazards.

Procurement of Finishing Materials

Purchase Specification. After selecting the desired finish, a purchase specification is written for the procurement of the materials necessary for the operation of the finish. This is done in collaboration with prospective vendors, the laboratory, purchasing department personnel, and the finishing foreman. A draft copy of the specification is then sent to each for comment and approval. When the specification is officially released, there is absolute agreement among all concerned.

Specifications serve as a protection for both the buyer and seller. The buyer knows what to check for, and the seller knows what the customer wants.

Much has been written about the prepara-

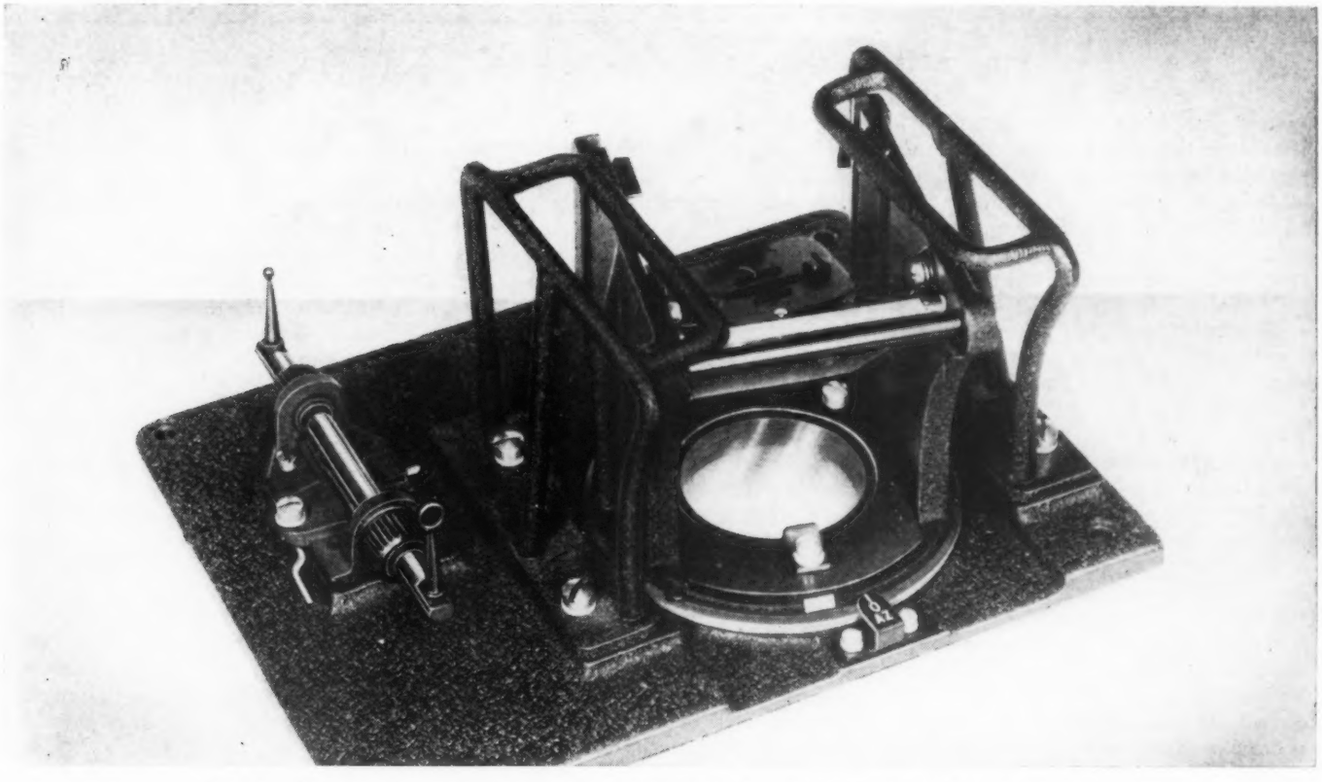

Fig. 1—Paints or lacquers for parts used in optical systems must not fog the lenses.

SPERRY GYROSCOPE COMPANY, INC.

Brooklyn, New York

Engineering Division — **SPECIFICATION** — Standards Department

TITLE: Purchase Specification for Cellulose Nitrate Lacquer Thinner.

SCOPE:

1. This specification records the purchase requirements for cellulose nitrate lacquer thinner.
2. This material is intended for use with cellulose nitrate lacquers covered by Sperry specification P.690,162.

MATERIAL AND WORKMANSHIP:

3. Material.—Ingredient materials used in the manufacture of this product shall be of high quality, entirely suitable for the purpose.
4. Workmanship.—The component ingredients shall be intimately assembled and processed in accordance with the best practice for high quality lacquer thinners which are stable and not subject to abnormal change with age in sealed containers.

DETAIL REQUIREMENTS:

5. Appearance.—The appearance shall be clear and free from suspended matter and sediment when examined by transmitted light.
6. Color.—The color shall be water white when compared to distilled water.
7. Odor.—The odor shall be mild and not noticeable after drying from filter paper.
8. Cleanliness.—The thinner shall show complete evaporation from filter paper.
9. Specific Gravity.—The specific gravity at 68° F. shall be between 0 80 and 0.83 (6.67 and 6.92 lb./gal.).
10. Distillation Range.—The distillation range shall be between 158° and 320° F.
11. Flash Point.—The flash point shall be 35° F. minimum.
12. Copper Corrosion.—The thinner shall not blacken or corrode clean metallic copper when immersed in the fluid for 24 hrs. at room temperature.
13. Blush Resistance.—When used with cellulose nitrate lacquers covered by Sperry Specification P.690,162, there shall be no blushing at 70% relative humidity and 80° F.
14. Solvency.—The thinner shall be rich in solvent power. Dilute one part of Sperry approved lacquer with an equal part of this thinner. Add a third part of toluol slowly and with vigorous stirring, and allow to stand for 2 hours. No precipitation shall occur.

INSPECTION AND TESTS:

15. Inspection:
    a. The material shall be subject to inspection by authorized inspectors. When inspection is conducted at the manufacturer's plant, tests shall be conducted by the manufacturer under the supervision of the authorized inspector.
    b. Acceptance or approval of material in course of manufacture shall in no case be construed as a guarantee of the acceptance of the finished product.
16. Tests.—Tests shall be conducted by the manufacturer from time to time to determine conformance with all the requirements specified herein.
17. Sampling:
    a. The manufacturer shall furnish one quart of the approved thinner to be retained as a standard against which subsequent deliveries shall be compared.
    b. With each order supplied, the manufacturer shall furnish to the Materials Laboratory of the Sperry Gyroscope Company one pint sample representative of the material purchased. The purchase order against which the sample has been issued shall be indicated.
    c. Sample shall be furnished free of charge, and shall be in addition to the quantity ordered.

GENERAL CLAUSES:

18. Packing.—In accordance with the best practice, all material must be packed to withstand shipment and be given ample protection against damage.
19. Marking:
    a. Each can shall be marked with a description of the contents, the manufacturer's name and product number, and the Sperry Gyroscope Company's specification number.
    b. Each shipping container shall be marked with a description of the contents, the quantity contained therein, the manufacturer's name and product number, and the Sperry Gyroscope Company's specification and purchase order numbers.

REJECTION OF MATERIAL:

20. Failure to meet any of the above requirements shall be sufficient cause for rejection, and the Sperry Gyroscope Company reserves the right to reject any portion or all such material under the terms of the order covering the purchase of the material.

CONDITIONS OF OFFICIAL ORDER:

21. This specification shall be considered as subject to all conditions forming part of the Sperry Gyroscope Company's purchase order.

APPROVED PRODUCTS:

22. The list below contains the names of manufacturers whose product has been tested and approved by the Sperry Gyroscope Company, Inc., as conforming to the requirements specified herein.
23. Thinner furnished by the manufacturers shall be equal to the sample submitted for test and approval, and the furnishing of material which proves to be unequal to the original sample will be sufficient cause for removing the manufacturer's name from this approved list.

Manufacturer	Brand Name
1. E. I. duPont de Nemours & Co., Inc.	Thinner #3600
2. Coating Materials Laboratories, Inc.	Thinner #120
3. Roxalin Flexible Finishes, Inc	Thinner #3260
4. Berry Brothers, Inc.	Thinner #LT-50

Fig. 2—Typical form and style used for purchase specifications.

tion of specifications. It will suffice to state here that the purchase specification should not be made so rigid or impracticable as to be impossible of fulfillment. It must be clearly written, free of unimportant details, and in a manner that leaves little room for misinterpretation. Performance requirements rather than physical or chemical requirements should be stressed wherever possible. Fig. 1 shows a typical Sperry purchase specification for a finishing material.

Approved Sources of Supply. After the establishment of the specification, vendors are asked to submit final samples for testing in the laboratory. Those that qualify are placed on a list of approved suppliers. The purchasing department may buy only from these approved sources of supply. Once the vendor has been approved, the only concern of the standards engineer is the maintenance of the quality of the material. If the quality deteriorates, the vendor is so informed and given opportunity to restore the material to its original quality. If the trouble persists, the vendor is removed from the list.

The standards engineer works closely with the purchasing department in setting up the approved sources of supply. When a finish is standardized, the prospective list of manufacturers of the required materials is submitted to the purchasing department for comment. The purchasing department is asked to submit the names of any other manufacturers to whom consideration should be given. If, after the list of approved vendors is released, the purchasing department finds that more sources of supply are needed, it requests that additional suppliers be investigated and approved.

This practice of purchasing materials from lists of approved suppliers has many advantages. It provides the purchasing department with ready sources of supply for each material, thereby facilitating the placing of orders and the obtaining of quick deliveries. It gives the purchasing department the security that comes from knowing that it is buying from vendors whose facilities and capacity to produce have been surveyed, and who have been instructed fully concerning the requirements of the material.

Numerous benefits are also derived by the standards engineer. Lists of approved suppliers enable him to exercise full control over the quality of the materials and finishes. Since he investigates and approves all vendors, he comes in contact with the personnel of the manufacturers seeking business and thereby receives a steady stream of information on new and improved materials and finishes. The lists also help him to obtain the technical information needed for writing the company standard and specifications, since the manufacturers are dependent on him for approval.

Application of Finish in Shop

Manufacturing Specification. The manufacturing or processing specification for producing the desired finish is next drawn up. This specification covers in detail the requirements for equipment, the preparation and maintenance of solutions, the operations and step-by-step procedure for the application of the finish, precautions, inspection and tests, and approved materials. Fig. 2 shows a Sperry manufacturing specification.

The manufacturing specification is made as simple as possible. Instructions are pre-

scented clearly and concisely, free of unimportant details, and in language that is readily understood by the average shop man. Experience has shown that unless this is done, the shop man will avoid using the specification and improvise his own methods, usually to the detriment of the finish produced.

SETTING UP OF FINISH IN SHOP. The work of the standards engineer does not end with the issuance of the manufacturing specification. He works closely with the plant facilities department and acts as technical consultant in the procurement of equipment and in setting up of the finish in the shop. There are many kinks to be worked out in the application of the finish during the initial run of production. The standards engineer works closely with the finishing foreman in ironing out any such difficulties.

When trouble occurs in the course of regular production, a works laboratory technician is detailed to locate the source of trouble. He tests the materials used, analyzes the solutions, and checks to see whether all of the procedures and requirements of the manufacturing specification are followed. In nine times out of ten, the technician is able to correct the trouble by pointing out to the operator wherein he had deviated from the specification. When the trouble is not caused by improper carrying out of specification procedures, an extensive study is undertaken in the laboratory. If the fault lies with a material, the vendor is called in and an attempt is made to restore the material to its original quality. If the fault is such that modification of the solutions, methods, or procedure is required, the specification is revised and re-issued, and the functioning of the modified finish is again checked in the shop.

Publicizing of Standardized Finishes

The last phase of standardization is that of publicizing the finishes that have been standardized. This is done in two ways; first, by publishing information relative to the standard finishes, and second, by consultation work.

STANDARDS MANUAL. Engineering Standards are written for the standardized finishes, giving pertinent information relative to their use, application, characteristics, and limitations. These standards are filed in a loose-leaf folder known as the Materials and Processes Manual. The manuals are distributed to personnel throughout the company. With these standards at their disposal, the engineer, draftsman, shop foreman, inspector, purchasing agent, and other company personnel can find the specific information they may seek about the finish.

Since the use of standard finishes is almost entirely on a voluntary basis and the product engineer has the final authority in the selection of finishes, the success of the standardization program lies in the ability to make the engineer want to specify standard finishes. This is done, first of all, by making the standards work of such

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SPERRY GYROSCOPE COMPANY, INC.
Brooklyn, New York

Engineering Division — **SPECIFICATION** — Standards Department

TITLE: Manufacturing Specification for Finish No. 43—Black Dip on Stainless Steel.

SCOPE:

1. This specification records the process to be used to secure the applied coating listed as "Black Dip on Stainless Steel" and referred to as Finish No. 43 in Standard Practice Instructions 4.2.6.3.
2. This chemical dip process is applicable to stainless steels, wrought and cast, of both the austenitic (18-8) and ferritic (straight chromium) types. It imparts a dull black color to treated parts.

APPLICABLE SPECIFICATIONS:

3. The following specification forms part of this specification: M.55200—Manufacturing Specification for the Cleaning of Metal.

DESCRIPTION:

4. Type.—The process covered herein is a method of forming a black protective film on stainless steel parts by means of a chemical dip.
5. Process.—The process to be used shall be the one known commercially as the "PX Process", a product of the Heatbath Corporation of Springfield, Massachusetts.

GENERAL REQUIREMENTS:

6. Solutions:
   a. Sulfuric-Acid Solution.—The sulfuric acid solution shall contain approximately 15% by volume of concentrated sulfuric acid. It can be prepared by adding 1½ gallons of concentrated acid to each nine gallons of water. CAUTION: Pour water into the tank first, then add the proper amount of acid with thorough stirring. Never pour water into the acid. This solution is operated at 180°-200°F (83°-93°C).
   b. PX Solution.—The PX Solution is prepared by adding approximately 5½ lbs. of PX No. 1 salt to each gallon of water and heating slowly to boiling temperature. Add the salts slowly at first because heat is generated when they dissolve. A PX solution of proper concentration should boil at 255°-265°F (124°-130°C). The solution shall be kept boiling at a temperature of 255°-265°F by the addition of PX No. 1 salts, water or heat. A careful record must be kept of the amount of PX No. 1 salts which have been added. When the full volume desired is attained, and all the salts are dissolved, and the bath is boiling moderately at 255°-265°F, total the amount of PX No. 1 that was used to charge the tank. PX No. 2 is now added to the solution. For each pound of PX No.1 that was used, one ounce of PX No. 2 is required. This solution is operated at boiling temperature.
7. Equipment:
   a. Sulfuric Acid Tank.—The sulfuric acid tank shall be constructed of lead-lined steel. Hoods or ducts should be provided for removal of fumes. Automatic temperature control is recommended but is not absolutely essential.
   b. PX Solution Tank.—A black-iron or steel tank is satisfactory for holding the PX Solution. Hoods or ducts should be provided for removal of fumes. Automatic temperature and water volume control is strongly recommended but is not absolutely essential.
   c. Wires, Clamps, etc.—Wires, clamps, perforated containers, etc., required for suspending parts in the solutions should preferably be made of stainless steel. Plain steel may be used but will have to be replaced periodically due to gradual attack by the solutions. Soldered joints shall not be employed.

SOLUTION CONTROL:

8. a. The sulfuric acid solution shall be analyzed occasionally for acid content. Additions of water or acid shall be made to bring the solution to the proper concentration.
   b. The PX Solution is controlled by adding salts or water as required to maintain the boiling temperature at 255°-265°F. When it is necessary to add more salts, both PX No. 1 and PX No. 2 must be added in the proper ratio.

OPERATIONS:

9. a. Cleaning; b. Sulfuric Acid Dip; c. Rinse; d. PX Solution Dip; e. Drying.

PROCEDURE:

10. Cleaning.—Parts shall be thoroughly cleaned of oil, grease, dirt, scale, rust, etc., employing an alkaline cleaner, in accordance with Specification M.55200.
11. Sulfuric Acid Dip.—Immediately after cleaning, immerse parts in the sulfuric acid solution maintained at 180°-200°F. for 30 seconds to 1 minute.
12. Rinse.—Rinse parts immediately after the sulfuric acid dip. Do not expose parts to the atmosphere any longer than necessary to transfer to the rinse tank. Agitate the work in the rinse. Do not rinse longer than necessary to completely remove the acid.
13. PX Solution Dip.—Dip parts in the PX Solution at 255°-265°F and allow to remain for 15 to 20 minutes.
14. Rinse.—Rinse parts thoroughly in cold running water.
15. Drying.—Parts may be dipped in hot water to facilitate drying, then dried in a hot or cold air blast.

PRECAUTIONS:

16. Do not attempt to treat parts of lead, tin, zinc, cadmium, aluminum, brass, bronze or copper by this process as they may be attacked by the solutions.
17. Do not treat assemblies of stainless steel parts, as the PX residue remaining in the seams will be very difficult or impossible to remove during the washing and drying operation, thereby creating a pocket for corrosion.
18. On cooling to room temperature, some of the PX salts may crystalize out and settle to the bottom of the tank. On reheating, the tank should be stirred to break up the crystal mass and aid in resolution of the salts.
19. a. Operators of the PX Process should be provided with suitable goggles, rubber gloves and rubber aprons. Contact of the sulfuric acid or PX Solutions with the skin should be avoided.
    b. Should PX Solution come in contact with the skin, wash immediately in cold water until free from salts and apply a saturated solution of boric acid in water.

APPROVED MATERIALS:

PX Salts No. 1 & No. 2, Sperry Spec. P.690,329.
Concentrated Sulfuric Acid, Sperry Spec. P.690,100.

Fig. 3—Typical form and contents of manufacturing specification for a finish.

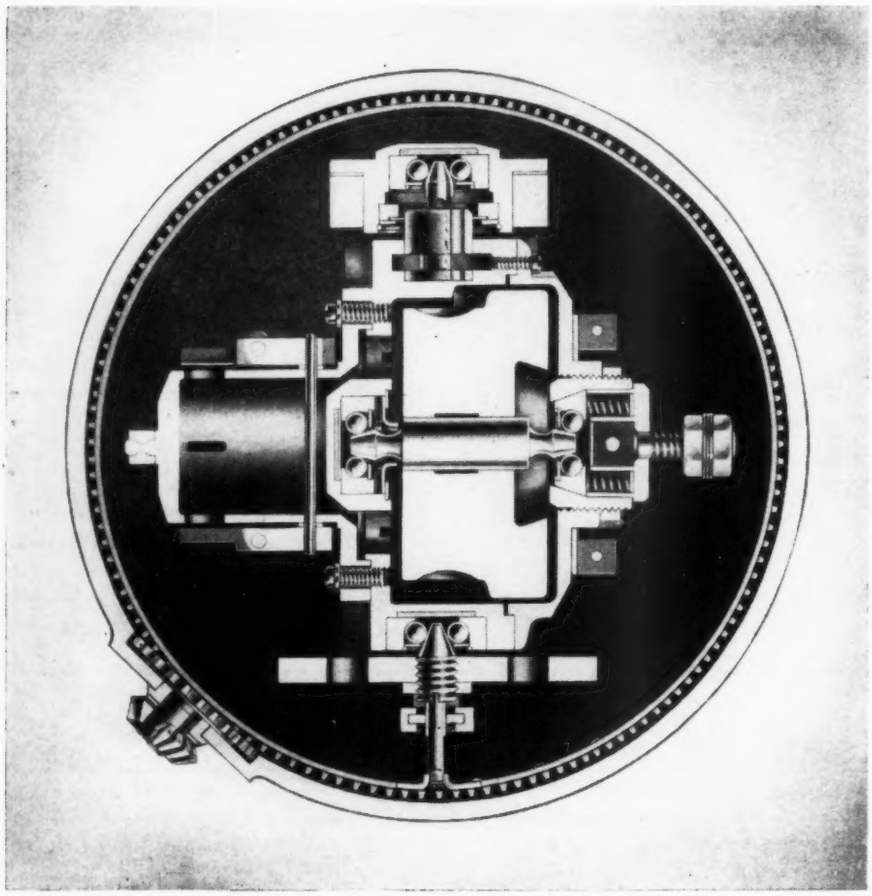

Fig. 4—Ground and polished chrome carbon steel pivots are given a chemical dip black oxidizing treatment that produces no build-up.

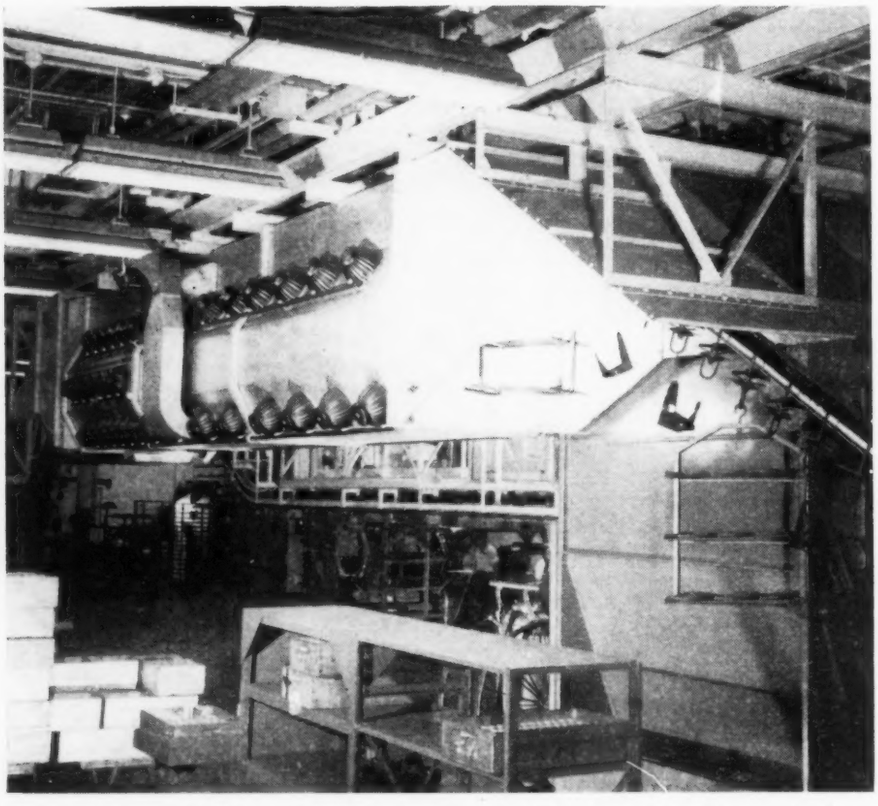

Fig. 5—Infra-red baking of finishes is economical for large quantity production.

quality and technical excellence that it has the respect of the engineers, and secondly, by placing the information at their finger tips.

Although selection is voluntary, standardization of this kind has resulted in almost 100 percent use of standard finishes. For finishes not covered in the manual, the engineer or draftsman must consult the standards engineer for information on equipment, specifications, correct drawing designation, and the like. This procedure enables the standards engineer to question each new finish and to make recommendations for the use of standard finishes.

Consultation Work. In addition to the published work, there are many other ways in which engineers, designers, draftsmen, and other company personnel are made "standards conscious." At the Sperry Gyroscope Company, these men are encouraged to bring their finishing problems to the standards engineer. From the mass of information accumulated over a period of years, and from his experience and specialized training in materials, metallurgy, finishes, shop processes and design, the standards engineer is in an excellent position to render immediate and effective service.

If the standards engineer does not know the answer to a problem, he makes it his business to find the answer. Thus he may make a search of the literature on the subject, consult outside firms, call in experts, and run experiments in the laboratory. The important point is that he finds the right answer. Unless the men receive prompt and satisfactory solutions, they will not bother coming back. In winning the confidence of the engineers, the standards engineer is able to "get in on the ground floor" and exert his influence in the research and development stage, making his task that much easier when the project gets to the production stage.

The Standards Department maintains complete files of government specifications; national standards and specifications issued by technical societies and associations; commercial catalogs; and technical literature. Cabinets containing sample displays of materials and finishes are maintained. Engineers and other personnel are urged to make use of these facilities.

In addition, the standards engineer conducts educational programs on materials and finishes standardization.

An important factor contributing to the success of the standards program is the well-defined policy of the management on company standards. Clear directives from engineering executives furnish indispensable support to standards efforts.

Acknowledgment. The author gratefully acknowledges the invaluable help and guidance given by E. C. Sparling, chief engineer, and H. J. Meyer, director of standards, Sperry Gyroscope Company, in furthering the art of standardization.

THE SOCIETY OF THE PLASTICS INDUSTRY

DESIGN STANDARDS FOR INSERTS

THEIR APPLICATION IN MOLDED PLASTIC PARTS

I. SCOPE

a. The technicians who were selected to prepare this engineering standard have endeavored to compile their own knowledge as well as that of the entire plastics industry in preparing this engineering information. Engineers having a reasonable knowledge of plastics and an acquaintance with inserts and their use will find this standard of value in the proper design and selection of inserts.

II. SCREW-MACHINE INSERTS

The use of inserts in every type of molding operation presents certain difficulties, which should be recognized by the user. Where inserts are required for purposes of adding to the strength of the hold down screws; for reasons of added life to the screw thread such as is required where covers must be frequently removed, etc.; for electrical conduction; or for numerous other reasons, then it must be realized that the addition of inserts will slow down the molding cycle and will add to the cost of production. However, ingenious design frequently demonstrates that inserts may be eliminated or that the metal parts may be added subsequent to molding, and that such metal parts may be added by automatic means at a rate faster than is possible by incorporating such parts in the molding operation. Very often a tapped hole in the plastic material, a drive

TABLE I

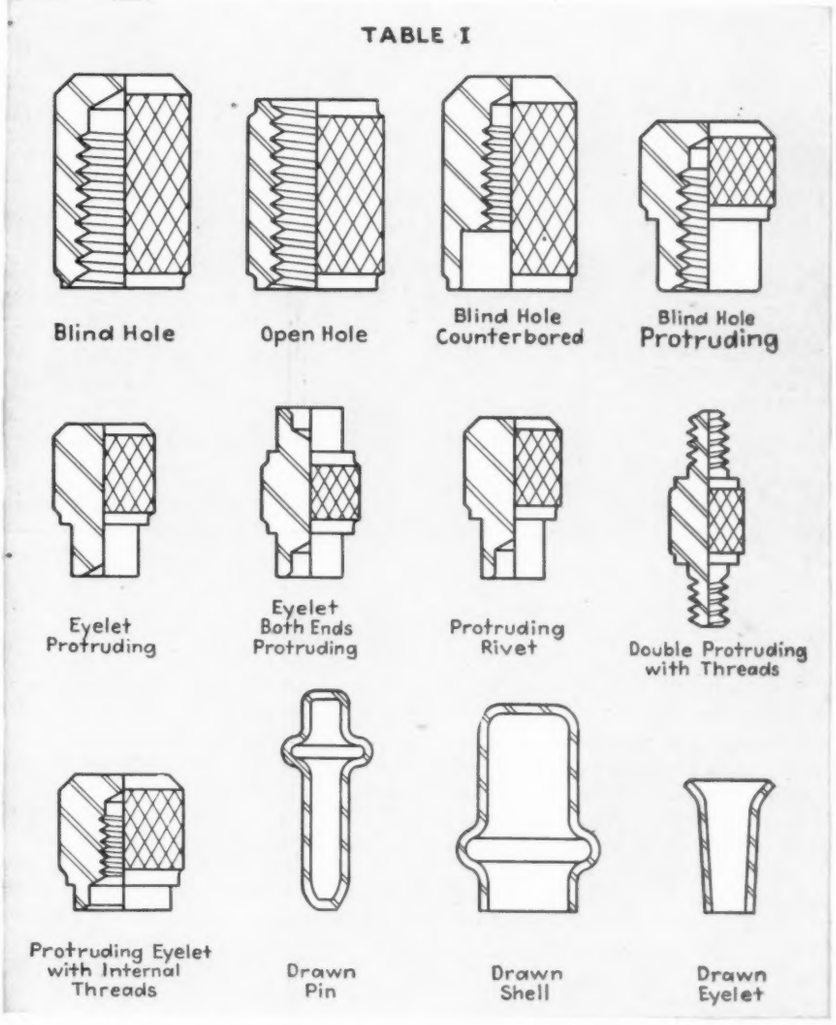

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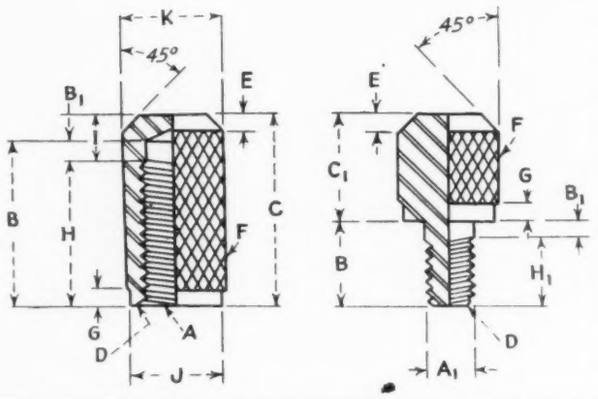
TABLE II



A	Tap size "American National" Class 2		
A-1	Major Diameter		
A-2	Minor diameter "Regular" tolerance		+0.0025"
	"Precision" tolerance		−0.0005"
B	Depth of minor diameter		
B-1	No. of unusable threads from bottom		(cut thread)
C	Length "Regular" tolerance		±0.010"
	"Precision" tolerance		±0.001"
C-1	Length of body male insert		±0.010"
D	Thread Chamfer	45°	±0.005"
E	Body chamfer	45°	±0.010"
F	Knurl		
G	Length of sealing diameter minimum		1/32"
H	Length of usable thread		1½ x diameter
H-1	Length of usable thread		H-1 = B-1 = B
I	Amount to add to H to obtain C.		H + I = C
J	Sealing diameter		±0.002"
K	Minimum bar stock diameter		

TABLE III—Non-ferrous Inserts With a Usable Thread Length Not More Than 1½ Times the Tap Diameter

A Coarse	A Fine	K	J	Tap Drill	A-2	A-1 Max.	A-1 Min.	B-1	I	D and E	Knurl
2-56		3/16	9/64	#50	0.0700	0.0860	0.0820	3	3/32	1/64	Fine
	2-64	3/16	9/64	#49	0.0730	0.0860	0.0822	3	3/32	1/64	Fine
3/48		7/32	5/32	#45	0.0820	0.0990	0.0946	3	7/64	1/64	Fine
	3/56	7/32	5/32	#45	0.0820	0.0990	0.0950	3	3/32	1/64	Fine
4/40		7/32	11/64	/43	0.0890	0.1120	0.1072	2 1/2	7/64	1/64	Fine
	4-48	7/32	11/64	#42	0.0935	0.1120	0.1076	2 1/2	7/64	1/64	Fine
5-40		1/4	3/16	#37	0.1040	0.1250	0.1202	2 1/2	7/64	1/32	Med.
	5-44	1/4	3/16	#37	0.1040	0.1250	0.1204	2 1/2	7/64	1/32	Med.
6-32		1/4	13/64	#33	0.1130	0.1380	0.1326	2 1/2	5/32	1/32	Med.
	6/40	1/4	13/64	#32	0.1160	0.1380	0.1332	2 1/2	9/64	1/32	Med.
8-32		9/32	7/32	#29	0.1360	0.1640	0.1586	2 1/2	5/32	1/32	Med.
	8-36	9/32	7/32	#28	0.1405	0.1640	0.1590	2 1/2	9/64	1/32	Med.
10-24		5/16	1/4	#23	0.1540	0.1900	0.1834	2 1/2	3/16	1/32	Med.
	10-32	5/16	1/4	#20	0.1610	0.1900	0.1846	2 1/2	5/32	1/32	Med.
12-24		3/8	5/16	#16	0.1770	0.2160	0.2094	2 1/2	13/64	3/64	Med.
	12-28	3/8	5/16	#13	0.1850	0.2160	0.2098	2 1/2	11/64	3/64	Med.
1/4-20		13/32	11/32	#6	0.2040	0.2500	0.2428	2	13/64	3/64	Coarse
	1/4-28	13/32	11/32	7/32	0.2187	0.2500	0.2438	2	11/64	3/64	Coarse
5/16-18		15/32	13/32	G	0.2610	0.3125	0.3043	2	7/32	3/64	Coarse
	5/16-24	15/32	13/32	I	0.2720	0.3125	0.3059	2	13/64	3/64	Coarse
3/8-16		9/16	15/32	O	0.3160	0.3750	0.3660	2	1/4	3/64	Coarse
	3/8-24	9/16	15/32	Q	0.3320	0.3750	0.3684	2	7/32	3/64	Coarse
7/16-14		5/8	17/32	U	0.3680	0.4375	0.4277	2	9/32	3/64	Coarse
	7/16-20	5/8	17/32	25/64	0.3906	0.4375	0.4303	2	1/4	3/64	Coarse
1/2-13		11/16	19/32	27/64	0.4218	0.5000	0.4896	2	5/16	1/16	Coarse
	1/2-20	11/16	19/32	29/64	0.4531	0.5000	0.4928	2	17/64	1/16	Coarse
9/16-12		3/4	21/32	31/64	0.4843	0.5625	0.5513	2	11/32	1/16	Coarse
	9/16-18	3/4	21/32	33/64	0.5156	0.5625	0.5543	2	9/32	1/16	Coarse
5/8		13/16	23/32	35/64	0.5469	0.6250	0.6132	2	3/8	1/16	Coarse
	5/8-18	13/16	23/32	37/64	0.5781	0.6250	0.6168	2	5/16	1/16	Coarse

screw, a self-tapping screw or bolt and nut can be used, with resultant saving in the cost of the molded part.

III. DIMENSIONS AND TOLERANCES

a. Maintaining a proper tolerance on various dimensions of inserts has always been a problem with the plastics industry as well as the insert manufacturers, mainly because of the lack of information on design and standardization of dimensions.

Although the ordinary screw-machine type round insert is common, numerous designs, as illustrated in the sketches on Table I, are used.

b. Dimensions and tolerances for the usual type male and female inserts in Tables II and III were compiled with the cooperation of the National Screw Machine Products Association as being practicable for machining as a single operation on an automatic screw machine, and hence are most economical.

Note that the dimensions given for tapped inserts apply only to non-ferrous metals where the depth of usable tapping is not more than 1½ times the tap diameter. On A-2 (minor diameter) and C (length of tapped inserts) the maximum "Standard" tolerance should be specified whenever possible. However, for closer tolerances "Precision" can be specified when necessary. To maintain the "Precision" tolerance, reaming and other additional operations will be necessary at additional cost.

c. If steel inserts are required, Tables II and III cannot be used in design without several modifications which will result in more expensive inserts than when made of brass or, in special cases, of aluminum.

IV. ANCHORAGE

a. Firm and permanent anchorage of inserts is essential and since there is no chemical or natural adherence between plastics and metal inserts, the anchorage must be obtained by mechanical means. The slight anchorage that is obtained by the shrinkage of plastic around the insert is never sufficient.

b. Inserts must be anchored sufficiently to prevent turning when torque is applied and to prevent pulling out of the plastic part when subjected to tension. However, internal stresses in the plastic molded part must be kept to minimum.

c. In the early days of plastics, it was customary to use hexagon stock for inserts, Fig. 1. This is mechanically incorrect except in some special applications. Hexagonal stock provides torsional anchorage only. Grooves must be machined to obtain sufficient anchorage in tension. Combination of sharp corners and grooves on hexagonal stock sets up certain internal stresses in the material which often result in cracking. In practically all instances, round stock is recommended so that a diamond knurling can be used. Diamond knurling provides the most satisfactory anchorage from the standpoint of torque and tension, and minimizes possible cracking around the insert. Knurling of inserts is best accomplished in screw machines with "end" knurling tools. The stock sizes given in Table III are ample to allow end knurling and to leave sufficient stock for a proper "sealing" diameter free of knurling at the open end of the insert.

d. Grooves can be used in conjunction with diamond knurl, Fig. 2. Sharp corners must be avoided when machining the grooves. When using grooves, provide one wide groove in the center of the insert rather than two grooves, one on each end. The center groove allows the material to shrink or creep toward the center and consequently results in minimum strain within the piece, thus eliminating possible cracking. Right and wrong designs are illustrated in Figs. 3 and 4.

V. TORQUE AND TENSION TESTING

a. A simple inexpensive method of test recommended. Fig. 5 illustrates the method for tension and Fig. 6 for torsion. When conducting the torque test, a line can be scribed on the surface of insert and plastic in order to detect the slightest possible turn.

b. It is essential that special hardened and ground screws be used to eliminate friction. The screws should be well lubricated before conducting tests. A standard graduated torque wrench is recommended. Results of the tests are indicated in in.-lb. torque.

VI. WALL THICKNESS OF INSERTS

a. Minimum wall thickness of metal on the inserts depends entirely upon the accuracy desired on the inside dimensions of the insert. If too thin a wall of metal is used, the combination of stress caused by shrinkage of the plastic material and by molding pressure may collapse the wall of the insert. As a result the diameter may decrease to a point out of the range of specified tolerances. Table III shows the minimum recommended diameters of bar stock for various sizes of inserts.

VII. SELECTION OF METAL

The correct selection of metal for inserts is essential because of the difference in the coefficient of expansion between various metals and plastic materials. Table IV lists the coefficients of expansion of various metals as well as various plastics.

VIII. MINIMUM WALL THICKNESS OF MATERIAL AROUND INSERTS

a. The thickness of the wall of plastic required around inserts depends upon (1) whether the material is thermoplastic or thermosetting, (2) type of material within each group, (3) shrinkage of material, (4) modulus of elasticity, (5) coefficient of expansion of the material, (6) coefficient of expansion of the metal used in the inserts, (7) temperature range over which molded part will have to function, (8) moisture-sensitivity, (9) loss of flexibility caused by aging, and especially (10) the design of the insert.

b. Often the molded part is designed first and the necessary inserts then fitted into the remaining space. If inserts are required, they should be considered first and then the molded part designed around them. The shape and form of the insert governs the wall thickness of material to a great degree, especially when the inserts are of irregular shape, rectangular, square, star, or of any other shape having sharp corners.

c. Two main factors in properties, especially of phenolic, urea and melamine materials, are modulus of elasticity and the ability of the material to cold flow after curing so that it can stretch slightly without cracking. No one property of the material will solve the problem. For instance, a material having low shrinkage of 0.002 in. per in. but having a rigid setting quality will crack. Other materials which have a shrinkage of 0.010 in. per in. but not as rigid a set, retaining some elastic properties, will not crack despite a minimum thickness of wall. It is impossible to set up comprehensive standards of wall thickness of material in relationship to diameters of inserts, particularly for some of the special designs. An insert ¼ in. diameter requires ⅛ in. wall

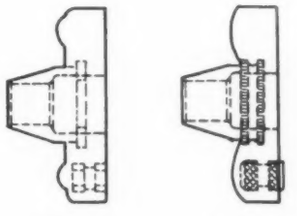


FIG. 1

FIG. 2

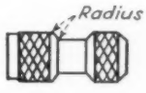


FIG. 3 (right)

FIG. 4 (wrong)

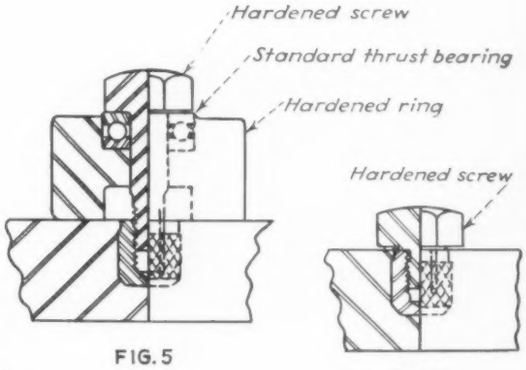


FIG. 5

FIG. 6

TABLE IV—Coefficient of Thermal Expansion (30-60 deg. C.) per deg. C.

Material	Coef. × 10^{-6}	Material	Coef. × 10^{-6}
Phenolics:			
General purpose	39	Cellulose acetate	80–160
Medium impact	38	Cellulose acetate butyrate	110–170
Medium impact—CFI—5	33	Ethyl cellulose	100–140
High impact—CFI—10	29	Urea formaldehyde	25–30
High impact—CFI—20	22	Melamine formaldehyde	25–30
Medium heat resistance	34	Vinylidene chloride	190
High heat resistance	26	Methyl methacrylate	70–90
Electrical general purpose	35	Polystyrene	60–80
Low loss	19	Polyethylene	180
Arc resistance	49	Nylon—Type FM-1	103
		Vinyl chloride-acetate	69

Material	Chemical Composition	Coef. × 10^{-6}
Aluminum 2S	99.2 percent Al	23.94
Copper	99.9 +	17.71
Phosphor Bronze 30	95.5 Cu, 4 Sn, 1 Zn	18.90
Phosphor Bronze		16.8
Brass Ordinary	67 Cu, 33 Zn	18.5
Bronze Commercial	90 Cu, 10 Sn	18.8
Steel	99 Fe, 1 C	12.
Stainless Steel	90–2 Fe + 8 Cr, 0.4 Mn, 0.12 C	11.
Nickel		12.9
Monel	60 Ni, 12 Fe, 11 Cr, 2 Mn	14.
Silver Standard	92.5 Ag, 7.5 Cu	18.
Zinc	95 Zn, 5 Al	28.
Solder Half and Half		24.
C. R. Steel		14.
Silver German		18.

TABLE V—Material Wall Thickness

Insert Diameters	1/8″	1/4″	3/8″	1/2″	3/4″	1″	1-1/4″	1-1/2″	1-3/4″	2″
Phenolics:										
General purpose	3/32″	5/32″	3/16″	7/32″	5/16″	11/32″	3/8″	13/32″	7/16″	15/32″
Medium impact	5/64″	9/64″	5/32″	13/64″	9/32″	5/16″	11/32″	3/8″	13/32″	7/16″
High impact	1/16″	1/8″	9/64″	3/16″	1/4″	9/32″	5/16″	11/32″	3/8″	13/32″
High heat resistant general purpose type	1/8″	3/16″	7/32″	1/4″	11/32″	3/8″	13/32″	3/16″	15/32″	1/2″
High heat resistant impact type	5/64″	9/64″	5/32″	13/64″	9/32″	5/16″	11/32″	3/8″	13/32″	7/16″
Low loss	5/32″	7/32″	1/4″	9/32″	3/8″	13/32″	7/16″	15/32″	1/2″	17/32″
Special for large inserts flexible properties	3/64″	7/64″	1/8″	5/32″	7/32″	1/4″	9/32″	5/16″	11/32″	3/8″
Cellulose acetate	1/8″	1/4″	3/8″	1/2″	3/4″	1″	1-1/4″	1-1/2″	1-3/4″	2″
Cellulose acetate butyrate	1/8″	1/4″	3/8″	1/2″	3/4″	1″	1-1/4″	1-1/2″	1-3/4″	2″
Ethyl cellulose	1/16″	3/32″	1/8″	5/32″	3/16″	7/32″	1/4″	9/32″	5/16″	11/32″
Urea formaldehyde	3/32″	5/32″	3/16″	7/32″	5/16″	11/32″	3/8″	13/32″	7/16″	15/32″
*Melamine formaldehyde (a)	3/32″	5/32″	3/16″	7/32″	5/16″	11/32″	3/8″	13/32″	7/16″	15/32″
(b)	1/8″	3/16″	7/32″	5/16″	11/32″	3/8″	13/32″	7/16″	15/32″	1/2″
Vinylidene chloride	3/32″	1/8″	3/16	3/16″	7/32″	1/4″	1/4″	9/32″	5/16″	11/32″
Methyl methacrylate	3/32″	1/8″	3/16″	1/4″	3/8″	1/2″	5/8″	3/4″	7/8″	1″
Polystyrene	3/16″	3/8″	9/16″	3/4″	1-1/8″	1-1/2″	1-7/8″	2-1/4″	2-5/8″	3″
Polyethylene	1/16″	3/32″	1/8″	4/32″	3/16″	7/32″	1/4″	9/32″	5/16″	11/32″
Nylon Type FM-1	1/16″	3/32″	1/8″	5/32″	3/16″	7/32″	1/4″	9/32″	5/16″	11/32″
Vinyl chloride-acetate	3/32″	1/8″	3/16″	1/4″	3/8″	1/2″	5/8″	3/4″	7/8″	1″

*Melamine formaldehyde (a)—Mineral filled melamine ignition material
(b)—Cellulose filled melamine electrical grade

whereas an insert 6 in. diameter might require 1½ in. wall of material, depending upon the factors mentioned. Each individual part presents different problems and must be engineered according to design of insert and material used. Table V shows recommended minimum wall thicknesses with plain round inserts for various plastics.

IX. PROBLEMS IN MOLDING USUAL TYPES OF INSERTS

a. Floating of Inserts. Floating of inserts can be controlled or prevented by several methods. (1) Tapering the retaining pins slightly, starting the taper at the fillet and carrying it up to ¼ of the length of the pin. In most cases 0.003 in. taper is sufficient providing that the maximum tolerances of the minor diameter is maintained. If too much taper is allowed for drive fit, the insert may pull out of the material. (2) It has been found that a straight knurl on the retaining pin provides sufficient holding surface. (3) Square retaining pins can also be used. (4) Split pins are practical on blind-hole inserts. (5) Spring tension pins in which the retaining pin is slotted and music wire inserted into the slot. This method presents difficulties because the slightest flow of material into the slot prevents the spring from functioning properly. (6) An extended shoulder can be provided on the insert, shown in Table II as *J* (sealing), and this shoulder allowed to enter into the mold proper. This is an ideal method of preventing the insert from floating although it is not permissible when inserts must be flush with the surface of the material. (7) On male inserts a taper hole can be provided for a drive fit if close accuracy of inserts is maintained. In such a case, 0.0005 to 0.001 in. is sufficient. If the insert is long enough, a small side hole can be drilled in the pin and music wire inserted to provide spring action. This spring action prevents the insert from floating in practically all methods of molding. The same method can be used for holding inserts in the top half of the mold. (8) There are occasions when a more precise location of inserts is desired and in this event, removable threaded pins are provided in the mold. Inserts are screwed to these pins. This procedure, however, increases cost of production. Subsequent removal of flash from the thread is in most cases avoided.

b. Crushing of the Insert. In transfer molding there are few difficulties with crushing of inserts if close tolerances on the length are maintained. In compression molding, however, when the insert must show on both sides and is molded vertically or in line with the press motion, crushing of inserts can be prevented by the use of preforms with holes to allow the preform to slip over the insert. Sliding pins are provided in the force plug, operated by spring, air, or hydraulic action. These pins are in a down position when the mold is being closed and they contact the surface of the inserts before the flow of material takes place. Since the pins are under constant pressure, no material can enter the insert. This method can be applied to blind or open hole inserts, and either top or bottom pins. Considerable pressure can be applied on the inserts. Actual tests on a brass insert ½ in. long, 6 x 32 thread, with $\frac{1}{16}$ in. wall, show that the insert withstands 6 cycles of 500 lb. total pressure with a reduction of 0.0005 in. in length. When the inserts are not of the through type but are close to the rear surface of the molded part, preheating of material and insert is recommended.

c. Flow of Material into an Open-Hole, Through-Type Insert. In transfer molding there is very little difficulty, if the length of the insert is maintained from 0.001 in. to 0.002 in. oversize. When the mold is closed, the insert is pinched in the mold, and it is impossible for material to enter. In compression molding, however, it is impossible to prevent material from entering the hole unless pressure type pins are used. The same method is used in the prevention of crushing of inserts. If pressure pins cannot be used, it is advisable, especially on larger inserts, to tap the inserts undersize before molding and retap to proper size after molding. Extreme care should be taken in retapping to prevent stripping of threads, especially if considerable material has flowed into the thread. On small inserts it is most economical to mold the insert with a drilled hole and to tap after molding.

d. Flow of Material into a Blind-Hole Insert. Difficulties with material flow into blind-hole inserts are not as numerous as with the open-hole types. In most cases such flow is caused by loose retaining pins which allow the insert to float with the flow of material; uneven machining on the face of the insert; or knurling on the entire outside diameter of the insert, leaving extended burrs on the face which do not permit the insert to rest flat on the surface of the mold or the surface of the retaining pin. In all cases it is good practice to provide a slight recess in the mold, accommodating the outside diameter of the insert. When the *J*-diameter, Table II, of the retaining pin is the same as that of the insert and sharp corners can be retained in the hole, 0.005 in. depth is suffi-

cient to prevent the plastic from flowing in. This method allows the insert to protrude above the surface of the molded part, and this is desirable, especially when electrical contacts are to be made.

e. Protruding Inserts. Protruding inserts are frequently required and are molded for specific purposes. In most cases the protruding section is used for assembly or for bearing points where mechanical action is required. In special cases, especially on large inserts where the molded part is subjected to considerable torque to obtain a tight connection, it is advisable to allow a hexagonal section of the insert to protrude above the molded surface for a wrench grip. Thus strain is applied on the insert rather than on the plastic.

Perfect anchorage is also necessary. Where a limited wall of material must be used, the anchorage section of the insert is turned and coarse diamond-knurled. A groove can be added to increase anchorage for tension. However, sharp corners must be avoided. In the event that the hexagonal shape is used for anchorage, sharp corners must be reduced by turning and grooves provided for tension anchorage. Fig. 7 shows recommended design.

X. COLD-FORGED INSERTS

a. There are no specific formulas controlling the relationships of the diameters and widths of collars to the shank or controlling the kind and variety of shapes like ribbed, finned, pinchneck, hexagon and so on, which may be combined with other symmetrical or unsymmetrical shapes in one piece. For each problem, therefore, the solution should be reached through cooperation between the designer of the molded piece and manufacturer of the insert.

b. In general, the volume or quantity needed to insure economical production by cold-heading is about the same as that needed by other production processes. As second operations are required, such as turning, drilling, tapping and others, larger quantities are needed.

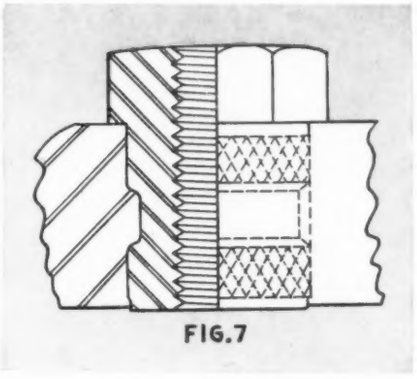


FIG.7

c. In the drawings, pages 36-37, made in cooperation with The Lamson & Sessions Company, Cleveland, Ohio, and Central Screw Co., Chicago, Ill., the parts, sketches, and data given are designed to indicate the potentialities of cold-head application. None of the inserts has been machined, but could be, of course, by either automatic or single-purpose equipment. Where additional machining, drilling, reaming or tapping would be involved, the tolerances will be the same as those listed in Tables II and III of the section on Screw Machine Inserts.

d. Material Specification. Almost any material can be cold worked, but cold working grades of the following are preferred in the order named: 1. aluminum and aluminum alloys, 2. brass, 3. copper and copper alloys, 4. carbon steels, 5. alloys steels, 6. stainless steels, 7. silver and other precious metals.

e. Tolerances Without Finishing Operations. The tolerances given for the parts in the layout are those ordered although closer ones could be met if necessary. Tolerances for any element such as length or diameter vary with the material and with the sizes and proportions of piece, since they in turn determine the equipment or method of heading to be used.

f. In general, the following tolerances can be considered as commercial without finishing operation, although in some cases special care must be exercised to meet them:

Length ..... ±0.010 in. (max.)
Fillets ..... Sharp or round, as specified
Diameter, 0.002 in. (minimum tolerance)
Squareness, shoulders or collars with shank ..... ±1 deg. (max.)

g. Tolerances with Finishing Operations. Whatever tolerance is needed can be met by adding finishing operations. For example, aircraft studs, bolts and specials are made in production today, commonly with tolerances as close as 0.0005 in.

XI. DESIGN OF SPECIAL INSERTS

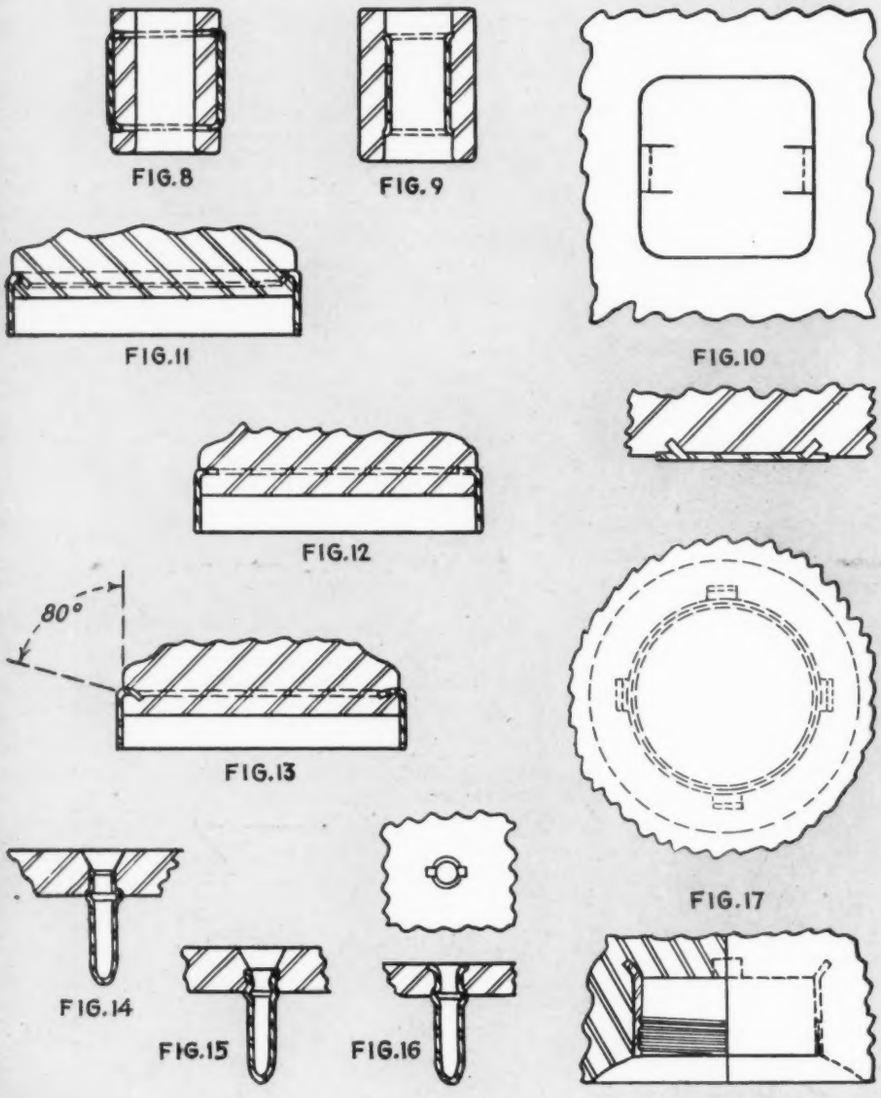
a. It would be an endless task to cover the entire field of special inserts. Some of the important phases of design will be covered in the succeeding paragraphs.

b. The design of special inserts for various applications requires as much engineering, if not more, than other phases of preliminary work. In many cases too little significance is attached to planning on special inserts. The design engineer, the manufacturer of the insert, and the molder must cooperate to obtain simplicity of insert design, which will result in the production of satisfactory parts and will aid in economical production.

c. Typical applications of special inserts are commutators, wire and insert-connections on telephone handsets and radio re-

XXI. NOMENCLATURE

Through-type	The insert is exposed on both sides of the material.
Blind-hole	Hole that is not drilled entirely through.
Open-hole	Hole is drilled through the insert.
Blind-hole partial thread	Thread is counterbored from the front for terminal or other assembly fit.
Protruding type	Part of the insert protrudes from the molded material.
Eyelet type	Part that protrudes from the material is used for spinning over in assembly.
Rivet type	Part that protrudes from the material is riveted in assembly.
Usual type	Inserts that are common to the plastic industry.
Anchorage	Part of the insert that is molded inside of plastic and held fast by the shrinkage of the plastic.
Retaining pin	Pin on which insert is placed and located prior to molding.
Floating of inserts	When pressure is applied on the mold and the material softens, it flows upwards. If the insert is loose on the retaining pin, some of the material flows under the insert or into the anchorage points and carries or flows the insert off the retaining pin.
Crushing of insert	When a protruding insert is molded in a conventional mold without any protection it will be crushed or collapsed by the material which flows into the hole provided for the protruded part in the upper part of the mold.
Flow of material into the insert	If a threaded open-hole insert is being molded, the retaining pin does not prevent the material from flowing into the insert unless the retaining pin is threaded which would increase the cost of molding.
Sealing diameter	Diameter of the insert which is free of knurl and is allowed to enter into the mold to prevent the flow of material.



sistors where carbon or other elements are molded inside of the plastic. A radio condenser is a good example of built-up laminated insert.

XII. SPECIAL ANCHORAGE OF INSERTS

a. Anchorage of inserts depends entirely upon the design of the insert, the thickness of the material to be molded around the insert, the type and nature of the material being molded, and the design of the molded piece. This point is discussed in paragraph IVa.

b. Thin Tubular Inserts. These are difficult to anchor properly. If a tubular insert is molded part way up a molded part, it is possible to invert a bead which will act as satisfactory anchorage. The bead method can be used on outside or inside inserts. Both methods are illustrated, in Fig. 8 for outside and Fig. 9 for inside types. A perforated surface around the circumference also can be used where permissible. When molding an outside tubular insert, it is often necessary to coat the inside of the insert with Neoprene or Vinylite to insure better bonding.

c. Flat Plate-type Inserts. These can be anchored by means of countersunk holes wherever permissible. Bevel all edges of the insert or, if certain sections of the insert are not required for the functioning of the part, the section can be partially cut out and bent over to provide anchorage. This method is illustrated in Fig. 10. If metal inserts must be thick, bosses can be extruded and slightly flared to act as satisfactory anchorage. Anchorage may also be obtained by spotwelding lugs to the underside of the insert.

d. Drawn Shell-type Inserts. Where a minimum wall thickness of plastic is specified and an insert of this type is used, caution must be exercised to provide proper anchorage. Fig. 11 shows unsatisfactory anchorage because it allows insufficient wall thickness of plastic to avoid cracking. Fig. 12 shows an insert which is fair in design and could be used to good advantage. In an insert of this type, the plastic has a chance to slide over the insert. However, to provide the best possible anchorage, the insert is flared in slightly, see Fig. 13. In this design the plastic actually has a chance to anchor the insert and to creep while shrinking.

e. Drawn Pin-type Insert. Often an insert of this type is molded into a plastic and then countersunk after molding as illustrated in Fig. 14. Although there is a slight bead provided as an undercut for anchorage, on an insert of this type it is entirely insufficient to hold the insert properly. Wherever possible when an insert of this type is used, piercing pins should be provided so that the insert can be pierced during the molding operation and the necessary countersink molded into the plastic. During this piercing operation the insert is flared out to provide proper anchorage in the plastic material as shown on Fig. 15.

Fig. 16 shows a drawn-type pin with an open end. Partial anchorage is obtained by shearing and folding two segments during the molding operation. Floating pressure-type piercing pins are recommended to minimize flow of plastic into the insert.

f. Drawn-shell Threaded Inserts. As illustrated in Fig. 17, these are often used on large molded parts where it is not necessary to have 75 percent of thread depth, or where insert space is limited. Because the shell is usually thin, approximately 50 percent of the thread depth is obtained. The four flared lugs provide a satisfactory anchorage in every respect. It is impossible to provide sealing points on an insert of this type, and hence, flow of material into the thread must be expected. Tapping after molding is recommended for most satisfactory results.

g. Intricate Inserts. An intricate insert is shown in Fig. 18. Considerable difficulty with cracking of plastic was encountered until aluminum inserts were selected. Actually there were two factors in favor of aluminum: coefficient of expansion and the ability of aluminum to give or spring slightly while the plastic was shrinking.

h. Large Surface Inserts. It is often necessary to mold one or more large surface inserts on one side of the plastic as illustrated in Fig. 19. Inserts of these types cause non-uniform shrinkage of plastic and considerable warpage. Regardless of type or method of shrinkage or cooling fixtures, it is certain that Surface A will be convex and B concave after the piece is allowed to cool and age. If a flat surface is required, the surface must be machined. Best results will be obtained when the parts are allowed to age before machining or, if possible, are baked in an oven for at least 72 hr. at suitable temperature.

i. Large Inserts with a Minimum of Wall Thickness of Plastic. Where a minimum thickness of plastic is allowed around a large insert and the part calls for thermo-

setting material, a special non-cracking type will generally have to be used. Care must be taken in the design of the insert to avoid sharp corners or other features which might create local stresses.

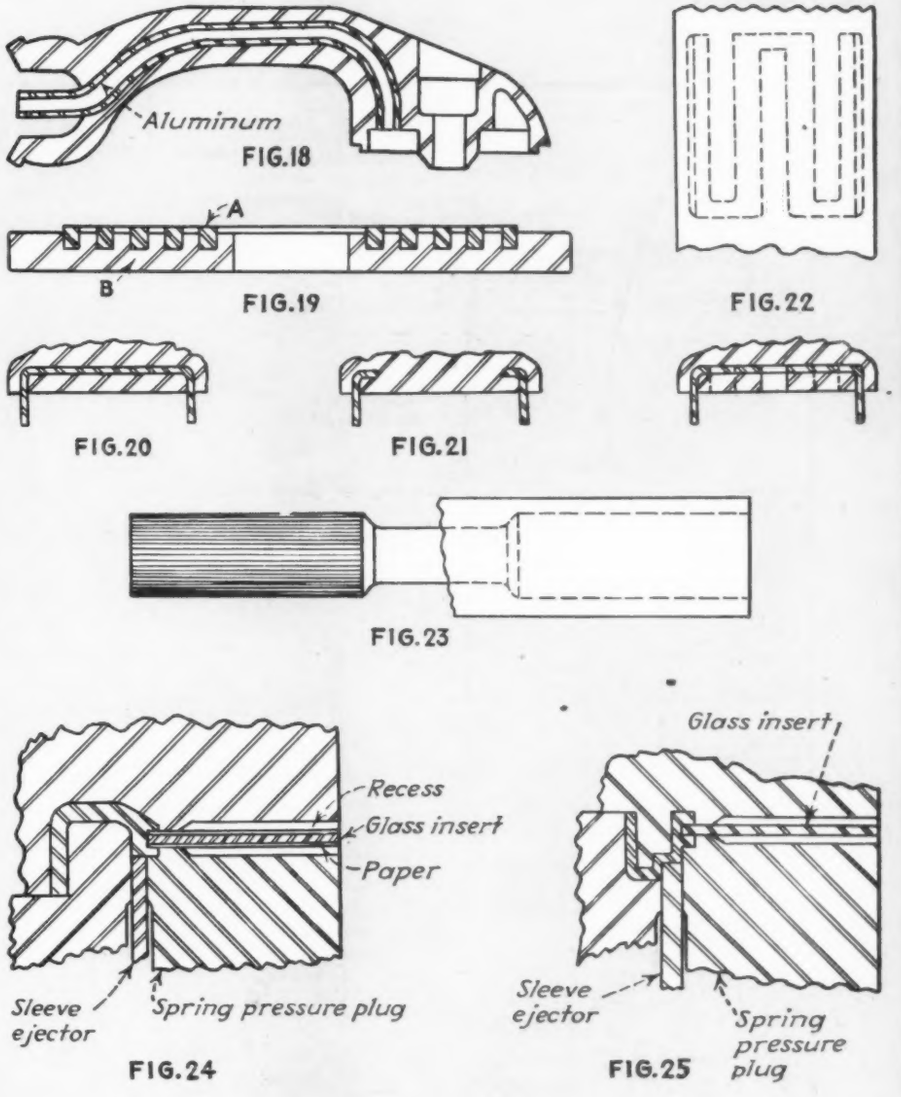
j. Irregular Shaped Inserts. These inserts cause the greatest difficulty. Fig. 20 shows a U-shaped insert approximately 1½ in. long, on which two rib projections are required above the plastic. From the standpoint of economy in forming this insert and loading it into the mold, it can be made in one piece but it will cause difficulty with cracking of the plastic. It would be more economical in the long run to make two separate inserts, as shown in Fig. 21. If electrical contact is required, a wire can be fastened between the two inserts; or if a more solid connection is desired, the insert can be made solid with cut-out slots, as shown in Fig. 22. Provision must be made in one half of the mold to prevent these slots from being filled with plastic. When these slots are open, there will be a slight give in the insert when the plastic shrinks. This will consequently reduce or eliminate the possibility of cracking of the plastic.

When a long bar-type insert is used, it is always advisable to provide an anchorage in the middle of the bar with grooves or slots, or coarse diamond knurl for round bars. See paragraph IVa. The center anchorage will allow the plastic to creep along the surface of the insert while it is shrinking towards the center. If additional anchorage is desired on round bars, the ends can be knurled with straight knurl, Fig. 23, and still retain the creeping action. Where dimensional accuracy is required, full allowance for shrinkage should be made. If the part is of cylindrical shape then, instead of a knurl, circular rings can be provided which will give satisfactory anchorage and at the same time allow the plastic to creep uniformly around the periphery of the insert. When a knurl is used on a piece of this type and the plastic begins to shrink, it has a tendency to climb up on the knurl, producing stress on the plastic and causing it to crack.

Inserts should be preheated (above the mold temperature if possible) prior to molding. This will allow the maximum expansion and improve the flow and cure of the material. On thermoplastic materials, preheating will eliminate the possibilities of weld marks which often result in cracking of the plastic after molding.

XIII. NON-METALLIC INSERTS

a. Inserts of various materials are used successfully. Wood inserts, for example, are used as a core especially for thermoplastic materials mainly in compression molding. The use of wood inserts in applications such as doorknobs or automobile gear-shift knobs saves considerable material and shortens the molding cycle.



b. Glass inserts are being successfully molded into thermoplastics by injection and into thermosetting materials by transfer. Difficulties can be reduced during the initial engineering of mold design. The most difficult problems are caused by the non-uniformity of contours and dimensions. Glass, being brittle, does not lend itself to the application of full clamping pressures during molding without the possibilities of breakage. It is necessary to provide a spring or rubber cushion to compensate for the normal irregularities. In some cases paper is glued to the surface of glass to provide additional cushioning and also to protect the surface from scratching during handling.

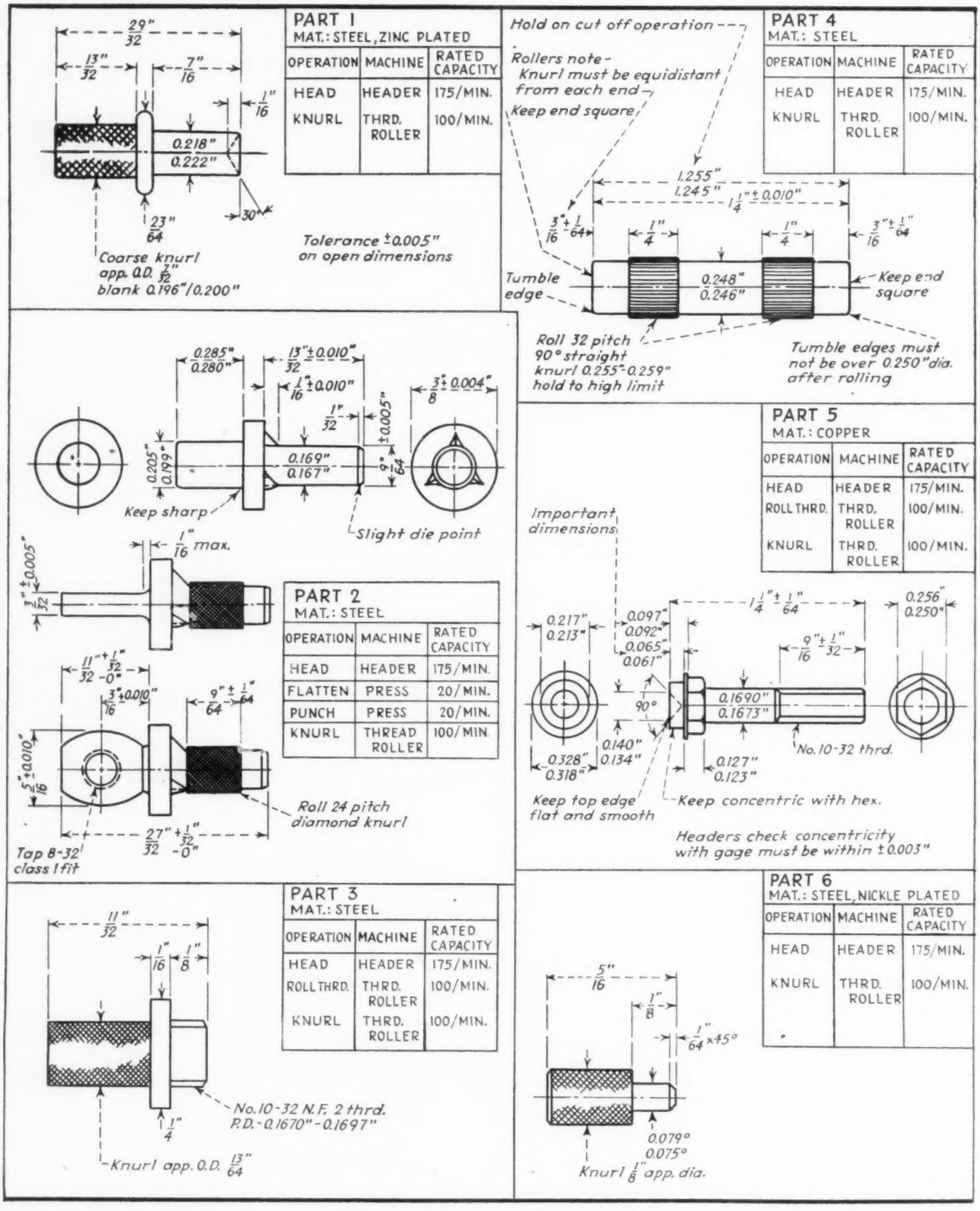
Locating the insert in the mold is difficult. Fig. 24 illustrates a sleeve-type ejector method. The inside sleeve diameter is of the same size as the glass insert. The insert is located by placing it inside the ejector sleeve when it is protruding in ejected position. Fig. 25 illustrates a step-molded part. One of the steps must be of the same diameter as the outside diameter of the insert. A sleeve-type ejector is used on this step. The insert is located in proper position by the inside of the sleeve.

It is recommended that all but a small outer surface of the pressure plugs be recessed as shown in Figs. 24 and 25. This will allow a small steel surface to contact with the insert and minimize the possibilities of breakage.

c. Porcelain in tubular form is used as an arc protecting material. In some cases a porcelain tube is placed over a wire insert and allowed to protrude from the plastic. In case of arcing the arc is on the porcelain instead of the plastic. Hard rubber and melamine inserts are used to prevent tracking, especially when revolving contacts are used.

XIV. LEAKPROOF INSERTS.

a. In many applications parts made of plastic are required to withstand high internal pressures. In molding inserts into such parts, because of numerous variables between plastics and metal inserts, the types of plastics, inadequate or improper anchorage, it is usually impossible to have


PART 1
MAT.: STEEL, ZINC PLATED
OPERATION | MACHINE | RATED CAPACITY
HEAD | HEADER | 175/MIN.
KNURL | THRD. ROLLER | 100/MIN.
Tolerance ±0.005" on open dimensions
Coarse knurl app. O.D. 7/32" blank 0.196"/0.200"
PART 2
MAT.: STEEL
OPERATION | MACHINE | RATED CAPACITY
HEAD | HEADER | 175/MIN.
FLATTEN | PRESS | 20/MIN.
PUNCH | PRESS | 20/MIN.
KNURL | THREAD ROLLER | 100/MIN.
Keep sharp
Slight die point
Roll 24 pitch diamond knurl
Tap 8-32 class 1 fit
PART 3
MAT.: STEEL
OPERATION | MACHINE | RATED CAPACITY
HEAD | HEADER | 175/MIN.
ROLL THRD. | THRD. ROLLER | 100/MIN.
KNURL | THRD. ROLLER | 100/MIN.
No. 10-32 N.F. 2 thrd. P.D. - 0.1670" - 0.1697"
Knurl app. O.D. 13/64"
PART 4
MAT.: STEEL
OPERATION | MACHINE | RATED CAPACITY
HEAD | HEADER | 175/MIN.
KNURL | THRD. ROLLER | 100/MIN.
Hold on cut off operation
Rollers note - Knurl must be equidistant from each end
Keep end square
Tumble edge
Keep end square
Roll 32 pitch 90° straight knurl 0.255"-0.259" hold to high limit
Tumble edges must not be over 0.250" dia. after rolling
PART 5
MAT.: COPPER
OPERATION | MACHINE | RATED CAPACITY
HEAD | HEADER | 175/MIN.
ROLL THRD. | THRD. ROLLER | 100/MIN.
KNURL | THRD. ROLLER | 100/MIN.
Important dimensions
No. 10-32 thrd.
Keep top edge flat and smooth
Keep concentric with hex.
Headers check concentricity with gage must be within ±0.003"
PART 6
MAT.: STEEL, NICKLE PLATED
OPERATION | MACHINE | RATED CAPACITY
HEAD | HEADER | 175/MIN.
KNURL | THRD. ROLLER | 100/MIN.
Knurl 1/8" app. dia.

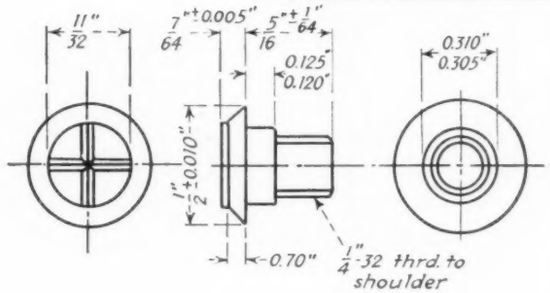
the insert remain airtight within the plastic, even when minimum molding pressures are used.

b. To retain a tight joint, a flexible wall must be provided between the plastic and a metal insert. When the molded part and the insert expand and contract under various conditions, this flexible material, although it consists of only a very thin coating, will compensate for the difference in coefficient of thermal expansion between metal and plastic.

c. A few successful methods are recommended. One method is to knurl the insert the same as for normal anchorage and provide at least two grooves, not necessarily too large, approximately 1/32 in. wide, 0.020 in. deep. The head or the anchorage part is then dipped in Neoprene, Vinylite, or other rubbery synthetic material, and then oven-dried before using. This

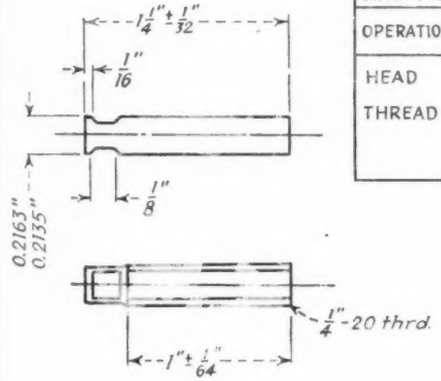
PART 7
MAT.: STEEL

OPERATION	MACHINE	RATED CAPACITY
HEAD	HEADER	175/MIN.
ROLL	THRD. ROLLER	100/MIN.



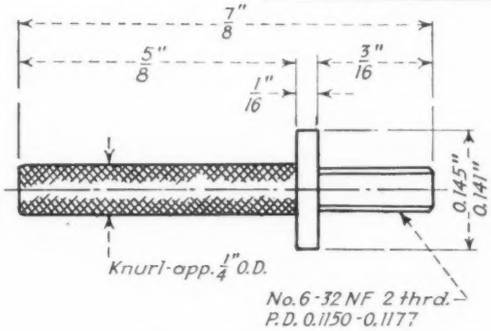
PART 8
MAT.: STEEL

OPERATION	MACHINE	RATED CAPACITY
HEAD	HEADER	
THREAD	THRD. ROLLER	40/MIN.



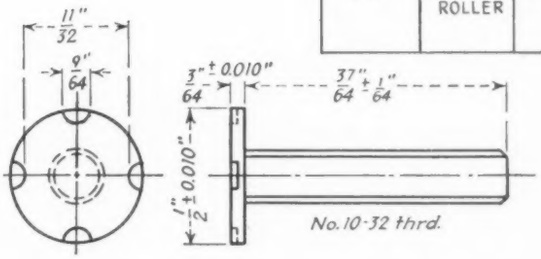
PART 9
MAT.: STEEL

OPERATION	MACHINE	RATED CAPACITY
HEAD	HEADER	175/MIN.
ROLL THRD.	THRD. ROLLER	100/MIN.
KNURL	THRD. ROLLER	100/MIN.



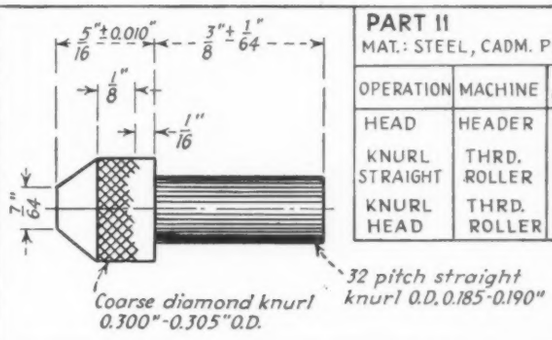
PART 10
MAT.: STEEL

OPERATION	MACHINE	RATED CAPACITY
HEAD	HEADER	175/MIN.
ROLL	THRD. ROLLER	100/MIN.



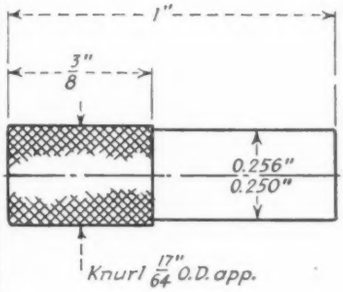
PART 11
MAT.: STEEL, CADM. PLATE

OPERATION	MACHINE	RATED CAPACITY
HEAD	HEADER	175/MIN.
KNURL STRAIGHT	THRD. ROLLER	100/MIN.
KNURL HEAD	THRD. ROLLER	100/MIN.



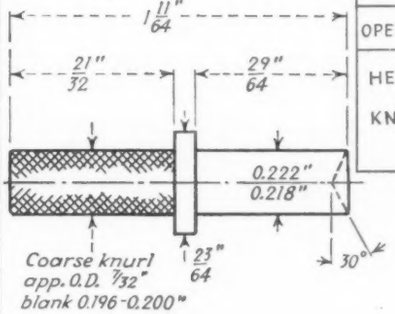
PART 12
MAT.: LOW CARBON STEEL

OPERATION	MACHINE	RATED CAPACITY
HEAD	HEADER	175/MIN.
KNURL	THRD. ROLLER	40/MIN.



PART 13
MAT.: STEEL

OPERATION	MACHINE	RATED CAPACITY
HEAD	HEADER	175/MIN.
KNURL	THRD. ROLLER	100/MIN.



process will supply sufficient coating on the insert to give it the necessary cushioning action and to provide the airtightness required.

It is possible also, especially on round inserts, to provide a groove in the anchorage head of the insert large enough so that a Neoprene washer can be used. Under normal molding conditions the washer will produce satisfactory results. On some applications a retaining groove is molded or machined between the insert and the plastic. This groove is filled with Glyptal and allowed to dry at room temperature or can be oven-baked if desired.

XV. SPECIAL INSERTS FOR REINFORCEMENT

a. In molding various parts from plastics it is often necessary to mold in inserts for reinforcements to provide greater strength, greater rigidity, greater safety (as in auto-

XX. "DON'TS" IN INSERT DESIGN

Don't use inserts if they can be avoided.
Don't mold a through-type insert unless the mold is designed for it.
Don't use an open-hole insert if it can be avoided.
Don't leave sharp corners on inserts. Chamfer wherever possible.
Don't try to mold inserts without proper anchorage.
Don't flatten inserts if the insert is loose on the retaining pin.
Don't put material into the insert to hold it on the retaining pin. This will require retapping.
Don't use inserts unless they are clean.
Don't use the drawn-type eyelets unless necessary.
Don't allow too thin a wall of plastic on back of the insert. A thin wall will bulge up and appear like a blister caused by undercure.
Don't allow too thin a wall of plastic around the insert because the plastic will crack.
Don't design the part or insert until the correct plastic has been selected for the application.
Don't carry the knurl out to the edge of the insert.
Don't try to mold long inserts supported on one end only.
Don't mold large inserts without heating the insert before molding in either thermosetting or thermoplastic materials.
Don't make the retaining pin too large or the hole for the male insert too tight. This will result in inserts pulling out of the material.
Don't use standard nuts and screws.

mobile steering wheels,) or greater dimensional accuracy.

b. In molding a thermoplastic housing for example, instead of molding a thick wall to obtain rigidity, a sheet metal reinforcement can be molded on the inside of the housing. This will not only produce greater rigidity with a minimum of wall thickness but it will also assist in maintaining better dimensional accuracy. Various materials can be used as reinforcement—molding board or Rogers board, laminated phenolics, perforated metal, metal screens.

XVI. PREPARATION OF INSERTS BEFORE MOLDING

a. Consideration should be given to cleaning or washing of inserts prior to molding, especially a screw machine product. If inserts are improperly washed, even though they appear clean, there may be some loose metal chips hanging on to the threads, or some fine metal dust in the knurls. This is often rolled into the surface by the process of knurling and it is not easily washed off, but it will be loosened by the flow of the plastic. These metal chips may flow up to the surface and consequently impair the appearance of the molded part. The most serious difficulty, however, is in electrical applications where a small particle or slight metal dust will cause a total breakdown electrically. Grease is also detrimental.

b. Cleaning processes are divided into three types:

(1) mechanical, including hand polishing, tumbling, shot- or sandblasting, solvent degreasing, alkali washing;

(2) chemical, such as removal of iron rust and silver tarnish by an acid bath;

(3) electrolytic cleaners.

Oil and machining chips can best be removed by a well stirred alkali bath followed by a rinse with hot water except where the nature of the metal, such as aluminum, rules out the alkali in favor of degreasing with solvent.

In many cases a reasonable amount of tarnish can do no harm but where the function or the appearance of the piece demands chemically clean inserts, an acid dip is necessary. For brass and bronze a mixture of nitric and sulfuric acids or nitric alone is commonly used.

Silver tarnish can be removed with nitric acid or a diluted solution of one of the cyanices. Oakite #32 has been found to be an efficient remover of iron rust.

c. Cleaning Flash from Inserts. Most flash difficulties can be avoided in the design of part and insert by providing sealing points so that the flow of plastic is cut off or at least minimized. However, even with the best design there will be some material on the inserts, especially when the mold wears or close tolerance on inserts is not maintained. When the inserts are plated and polished, there is a minimum possibility that flash will adhere. Several methods are recommended to minimize this. Lubricate the insert prior to molding with wax, soap, grease, or oil.

To remove the flash, cut it close to the molded part and peel it off. In most cases a mild solution of caustic soda will loosen the flash so that it can be removed easily. This method, however, requires extreme caution because too long a time or too strong a solution will harm the surface of the part and may even loosen the insert in its anchorage.

XVII. SALVAGE OF INSERTS

When the inserts are the through type, they can be knocked out by means of a foot press and fixture. When they are anchored part way in the material, a strong solution of caustic soda will loosen the inserts on thermosetting material so that they can be picked out. For thermoplastic material use suitable solvents for the plastic, or heat the parts in an oven and when the parts are soft, pull out the inserts.

XVIII. RELIEVING MOLDING STRESSES AROUND INSERTS

a. Considerable stresses are set up in molded parts of irregular design such as parts with thin and thick sections, and especially parts with metal inserts. The best method to relieve stresses is to allow the part to cool slowly. The ideal condition would be to carry the parts on a conveyor through an oven which has various stages of temperatures, starting at 50 deg. below the molding temperature, then gradually decreasing until the part is cooled down to room temperature. This method, however, requires special equipment.

The next best method requires two ovens, one at approximately 225 deg. F and one at 150 deg. F. The molded part remains in the oven until its temperature is reduced to oven temperature. The final step is room temperature. In case of thermoplastic materials, molding stresses are relieved by a baking process at suitable recommended temperatures.

XIX. METHOD OF PRESSING IN INSERTS AFTER MOLDING

a. It is often economical to press in inserts after molding. Best results are obtained when this is done at the press. In most cases a fixture is designed and mounted in a small arbor press or punch press. If there are several inserts in the part, they can be pressed in in one operation. The best anchorage is obtained when the inserts are pressed in immediately after the part is ejected from the mold.

When designing a mold for pressing-in inserts, consider the shrinkage of material, the size of the insert, and the allowance for anchorage. On small inserts it is safe to allow from 0.001 in. to 0.002 in. above the shrinkage of material. On large inserts, however, as little as 50 percent of the shrinkage is used for anchorage especially when there is a small wall of material. For example, if an insert 4 in. in diameter is to be molded with a ¼ in. wall of plastic, the plastic will crack. On the basis of 0.008 in. shrinkage per inch, the material will shrink 0.032 in. If the same insert is pressed in after molding and only 0.016 in. is allowed for anchorage, there will be no danger of cracking.

Both diamond and straight knurl give satisfactory results in pressing-in inserts. In certain instances for special applications, a coating of adhesive may be applied on the insert to help anchorage and assist in obtaining an airtight joint.

Friction Brake Linings
Types, Uses and Design Data

Six general types of brake linings are described briefly; some applications of the types are mentioned and illustrated; and the use of coefficients of friction, brake band or drum temperatures and wear data in selecting a lining during the design of brakes is discussed. The performance basis of selecting a lining in automobile service is explained.

BRAKE LININGS can be classified as (1) woven, (2) fabric, (3) dry mixed, (4) wire back, (5) extruded and (6) sheeter type. None of the types meets all the requirements for linings in today's brakes. Each type, though adaptable to a wide variety of operating conditions, has to be designed to function with the other members of the brake, particularly the shoe and the drum, if good performance would be assured.

WOVEN LININGS are one of the oldest types. In construction, this type is a solid tape, woven from asbestos and cotton yarn having a wire core. A soft brass wire is generally used in the core but alloy wires of lead and zinc are also common. The tape is impregnated with oils and heat-resisting compounds, cured by baking, and formed to size between rolls. Linseed oil, thermal setting resins, gilsonite, artificial asphalts, rubber cement, mineral oils, pitches and coal tars are some of the other constituents of brake linings.

FABRIC LININGS, also one of the oldest types, have a cloth base. The cloth is woven from asbestos and cotton covered wire. Pieces of the cloth 40 to 60 in. wide and a 100 yd. or more in length are common. After dipping in a light impregnating fluid, the cloth is passed between heated rolls where rubber or Buna S friction compounds are pressed into the spaces of the fabric. Brake linings of the fabric type are made of layers of the cloth, which can be built up by successive layers of equal width, by folding pieces of the cloth one or more times and by rolls that can be cut in segments. The lining is compressed during curing at pressures around 2,000 lb. per sq. in., which causes the built-up thickness to diminish by 25 percent. A curing temperature of 300 deg. F. or slightly higher is customary.

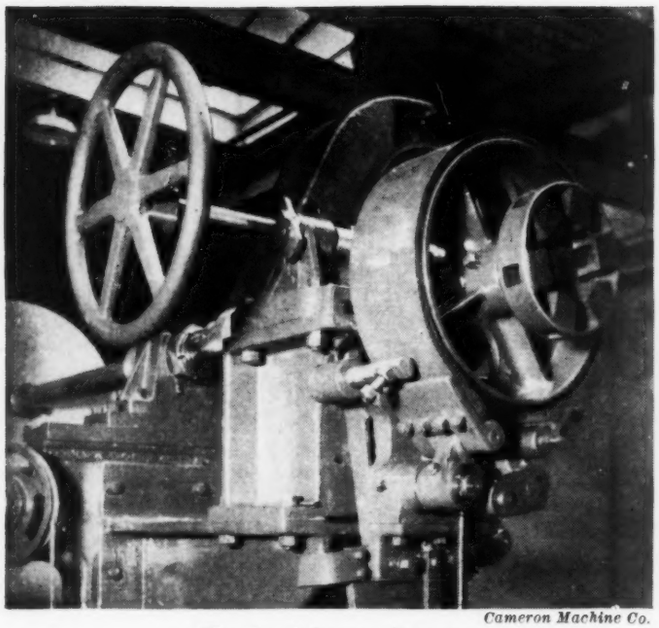
DRY MIXED LININGS are so named because the materials composing them are mixed in the dry state. The rubber and cotton ingredients are finely pulverized. Short asbestos fiber, almost a powder, is used. Sulphur, thermal setting resins and drying compounds are added in the powdered state. The thoroughly mixed materials are placed in a press under pressure of the magnitude of 2,000 lb. per sq. in. and heated. The heat softens the binder compounds. Continued heat and pressure harden the material, which upon cooling can be removed from the press in finished form. Generally the material is cooled and removed from the press in an uncured state, cut to size and cured in heated molds.

WIRE BACK LININGS contain a wire screen as reinforcement. The wire screen can be readily built into dry mixed, wet mixed and dough mixed linings. One method of applying the friction materials to the screen uses a pair of heated rolls of unequal diameters. The wire screen passes over the larger roll. The friction materials flow from a hopper to keep filled the space between the rolls as they revolve together. The lining in the pliable state is cut to size and cured in molds.

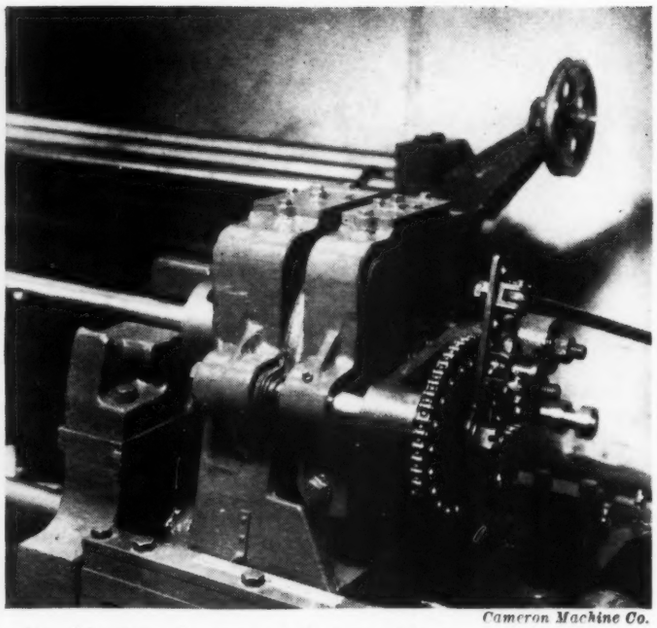
EXTRUDED LININGS get the name from the process of molding them. Wet mixed materials can be fed into the hopper of a standard extruding machine where they are forced by the revolving spiral blade through an orifice, which forms them to the desired width and thickness. A hydraulic ram is an

Fig. 1—An inertia brake dynamometer is often used in testing airplane wheel brakes under simulated landing conditions.

Hayes Industries, Inc.

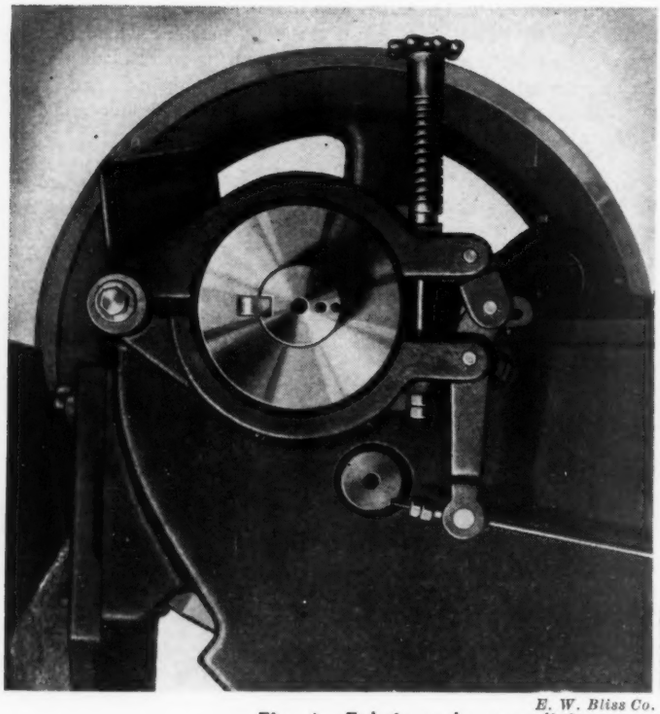


Cameron Machine Co.

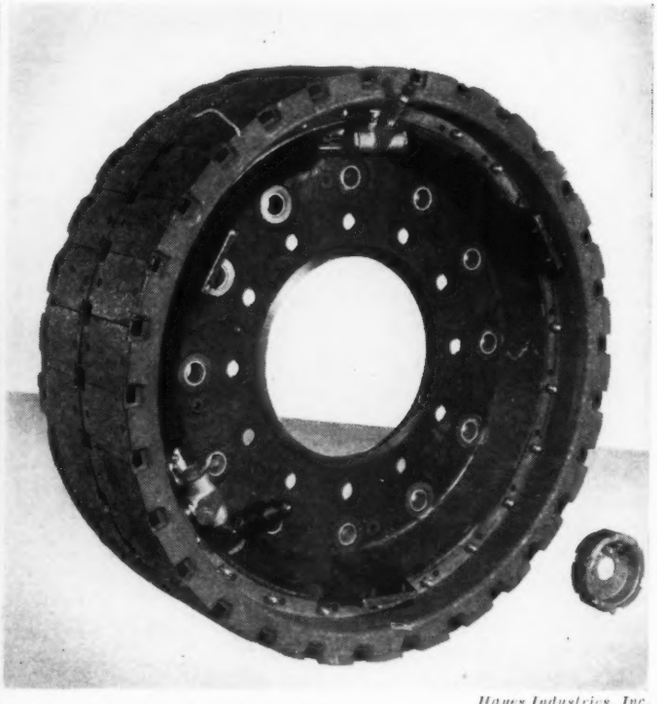


Cameron Machine Co.

Fig. 2—A heavy duty woven lining is used on band brakes of paper winding machines.
Fig. 3—Woven linings are also used on the disk brakes of paper machinery.



E. W. Bliss Co.



Hayes Industries, Inc.

Fig. 4—Fabric and woven linings are used on the band brakes of presses.
Fig. 5—Blocks of molded lining are used on expander-tube brakes of aircraft wheels.

alternate method of forcing the wet materials through the orifice. The extruded material is deposited on a slowly moving belt. Wire can be pressed into the partially dried lining at this stage if desired. The lining is then cut to size and cured.

Sheeter Lining is made on a "sheeter" machine, which is a modified rubber mill. The larger roll, which is 3 to 5 ft. in diameter and 10 to 15 ft. long, is heated. Mixed material is fed into the opening between them. The material clings to the heated roll. The thickness between the rolls is increased as material accumulates on the heated roll until the desired lining thickness is attained. Then the sheet is slit, removed from the roll, cut to size and cured.

The different types of linings are available in a great variety of styles, sizes, thicknesses, shapes and coefficients of friction. These data are available in lining manufacturers' catalogs, to which the designer is referred because they are too voluminous for coverage here. Friction blocks differ mainly from the other molded linings in that they are thicker, wider, and shorter.

General Application

Woven linings are widely used on the contracting members of external band brakes. The brakes of hoists, cranes, presses, winches, tractors and oil-drilling machinery are familiar examples. One reason for the choice of woven linings on

band breaks is the flexibility of the woven type of construction. The lining bends with the band without cracking. The flexibility allows the lining to adjust itself to irregularities in both the drum and the band, thereby attaining gradual engagement of the rubbing surfaces over large areas.

Another reason is the high coefficient of friction. Asbestos fiber, which constitutes from 50 to 80 percent of the volume, is a high friction material. It is a hard material too, being harder than the drum in some instances. The harder compounds, such as iron oxide, emery, cement and others, which are sometimes found in linings, can also be incorporated into woven linings.

A heavy duty woven lining is used on the band brake of the paper winder, Fig. 2. Fig. 3 shows a water-cooled disk brake having a woven lining. The lining is secured to both sides of the rotating steel disk, which is compressed between the water-cooled jackets during braking action.

Woven linings have been relegated to a secondary place in the automobile industry. They are used still on propeller shaft brakes and on some light types of war vehicles that are designed for operation in mud, sand and dirt.

The fabric linings are used on many industrial applications in types of service similar to those for woven linings. Fig. 4 shows an external band brake on a press. The purpose of the brake is twofold: It arrests the upward movement of the ram at the top of the stroke; it keeps the ram from descending except when tripped for a working stroke.

Fabric linings are used also on the expanding shoes of internal brakes. They are used to some extent on trucks and on war vehicles where operation in mud and grit are encountered. Fabric linings can be designed to have a wide range of friction coefficients and as either semi-flexible or rigid linings. They contain lower asbestos content than woven linings and consequently are easier on brake drums.

The dry mixed, wire back and extruded types, often designated collectively as molded linings, find wide application in automobile passenger cars. The wire back type is used on many trucks; the block type is common on the heavier trucks and on buses of medium and large sizes.

Molded linings can be designed with friction coefficients in the high, medium or low ranges, but linings in the medium friction range are the most frequent. Molded linings are dense, hard and rigid. The dough-mixed wireback type are slightly the more porous and have a little flexibility. All molded types should be ground to fit both the drums and the shoes.

Airplane wheel brakes of the expander-tube type carry thin blocks of molded lining; the disk type of wheel uses segments. Fig. 5 shows the friction blocks assembled on a large expander-tube type of wheel. The torque lugs in the frame not only position the brake blocks but also prevent them from rotating.

The disk-type railroad-car brake uses a molded block. Fig. 6 is a recent development in a small motor brake. The drum is a molded friction material. The brake band, when the motor switch is shut off, grips the drum from either direction of rotation, the motor being reversible.

Coefficients of Friction

Manufacturers and suppliers of brake linings describe linings as having high, medium and low coefficients of friction, frequently without designating a numerical range of the three classifications. Linings having friction values of 0.40, 0.30 and 0.20 are generally recognized as belonging respectively to the three ranges. Although opinions differ over boundaries of the three ranges, the values 0.35 and 0.25 represent convenient limits between them. Thus 0.30 plus or minus 0.05 would establish a range within which a medium friction material could reasonably be expected to fall.

Although manufacturers of brake linings are reluctant to limit themselves to a range of this magnitude, they have developed friction materials to the point where a designer can specify such a range of friction coefficients, supplemented by the conditions of the brake tests and service, and reasonably expect the manufacturers to furnish a product to meet the requirements. The importance of designing the band or the drum, whichever is the other member of the rubbing pair, to suit the brake lining should not be overlooked.

Temperature of Operation

Changes in temperature affect the behavior of a brake lining perhaps more than any other single condition, despite the fact that measurements of temperature are seldom made. Friction brakes convert energy of motion, usually rotation, into heat energy. The band or drum absorbs and dissipates the heat. The friction material absorbs practically none of the heat, but its surface temperature approximates that of the contacting band. Incandescence can be observed along the contacting edges under severe braking action.

Any lining subjected to braking action beyond its capacity will either disintegrate and fade or build-up and wear rapidly. Linings can disintegrate through softening and pulverizing of the bonding constituents. Vulcanized rubber softens at 300 deg. F. and thermal setting resins begins to carbonize at 600 deg. F. Asbestos fiber begins to lose water of crystallization at 700 deg. F. At 1,200 deg. F. all the water of crystallization is driven off, the fibers are close to glowing, and when cooled,

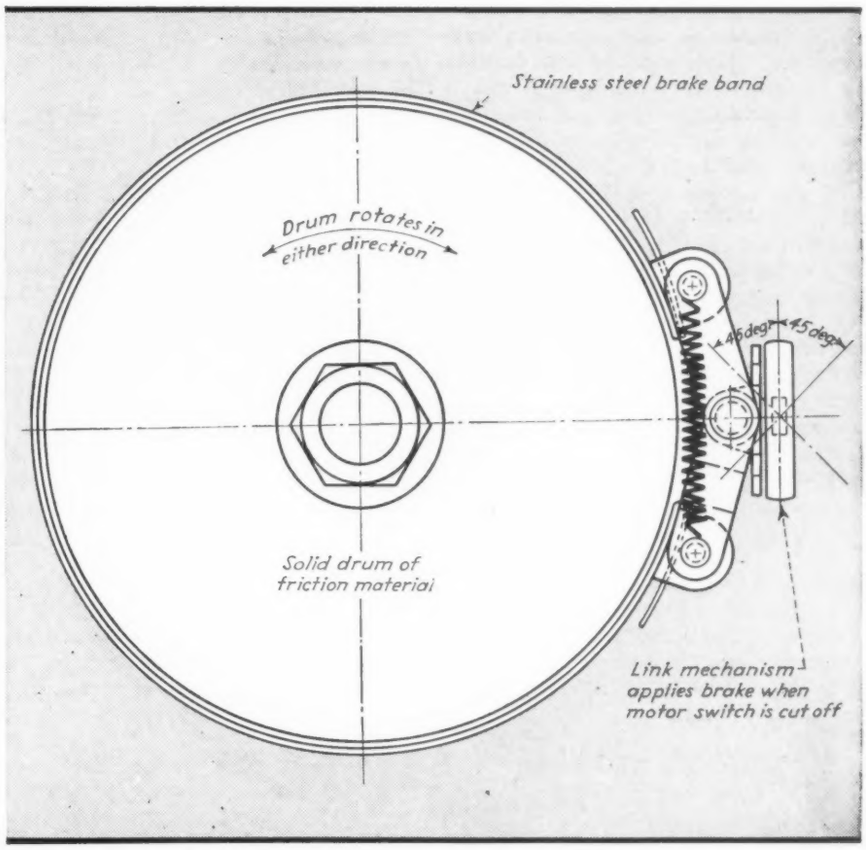

Stainless steel brake band
Drum rotates in either direction
45 deg
45 deg
Solid drum of friction material
Link mechanism applies brake when motor switch is cut off

Fig. 6—A recent design of a small motor brake in which the drum is a wheel of molded friction material and the rubbing surface is a flexible band of steel.

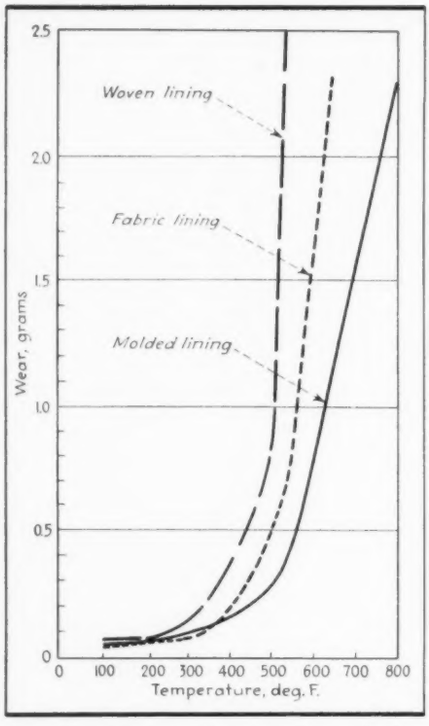


Fig. 7 — Curves showing the relative wear of lining materials at different temperatures.

the asbestos has been reduced to a fine white powder.

A lining is said to fade when its coefficient of friction diminishes under braking action. Sometimes the fade during a single application of the brake is meant; at other times the word denotes the falling off of brake effectiveness upon successive applications of the brake.

If the coefficient of friction increases when the brake is applied, the lining is said to build-up. Some linings soften and become sticky at moderate temperatures to exhibit an increase in friction coefficient. Abrasive action of either rubbing surface on the other hand also can cause build-up. Generally abrasive action is undesirable because the rapid wear associated with it shortens the life of the lining.

The curves of Fig. 7 indicate the relative wear of linings at different temperatures. They were drawn from data obtained from laboratory tests in which the wear was measured at constant temperature. Since brakes seldom operate at constant temperatures, the curves have little design significance; nevertheless they serve as a warning concerning what happens to brake linings if brakes are operated at high temperatures for prolonged periods.

Selecting a Brake Lining

The specification or selection of a lining in the design of a brake is not a simple matter. Long life and constant friction are incompatible with elevated temperatures of operation; hence brake designs represent compromises. As a consequence the selection of the lining is based on that condition of greatest moment in the predicted or known service of the lining. For example, some brakes must function in grease or oil. It would be folly not to place this condition foremost in designing the brake.

The coefficient of friction, the maximum temperature attained during braking service and empirical data often guide the designer through the drawing board stages of the design. Important brakes are proved under actual service conditions before the design is considered closed.

Whenever the coefficient of friction is used in computations, the values at the limits of the range are preferred to the mean value. The coefficient of friction is bound to fluctuate under service conditions and the effect of fluctuations should be studied and allowed for in the brake design. Brakes to absorb moderate or large amounts of energy seldom are designed on a basis of the coefficient of friction alone. Small brakes and brakes that prevent movement, but do not arrest motion, can be. Such brakes may be larger than necessary.

In calculations to determine temperature rises, all the energy of the arrested motion is treated as being converted into heat. Heat is dissipated while stoppage of the motion is in progress. Ten percent represents an average estimate of the amount of heat dissipated during generation so that 90 percent of the energy accumulates momentarily in the drum or band. The corresponding rise in drum temperature can be computed.

As an example suppose 6,000 ft.-lb. of energy is absorbed per sq. in. of swept area in an airplane wheel brake. This is the equivalent of 6,000/778 or 7.7 B.t.u. per sq. in. The disk is 5/16 in. thick and both sides are rubbing surfaces. Assuming ten per cent of the heat is dissipated immediately, 13.8 B.t.u. would be stored in a 5/16 cu. in. of the metal at the end of braking action. A temperature rise of about 1,300 deg. F. would be attained in a steel disk.

The amount of heat generated in stopping a 3,000 lb. automobile from 60 m.p.h. at a deceleration of 20 ft. per sec. per sec. is about 475 B.t.u. This is enough heat to raise the temperature of an ordinary 5/32 in. drum about 300 deg. F. A 3/16 in. drum would undergo a rise in temperature of 240 deg. F. upon absorbing an equal quantity of heat.

The two examples illustrate in a quantitative way the manner of using drum temperatures in computations. A comparison of some of the conditions of operation in the two kinds of service shows why the higher temperatures are tolerated in the brakes of airplane wheels. The brakes in automobiles are used oftener than those on aircraft; automobile brakes would be unsatisfactory to the customer if the linings wore as fast. Automobile brakes need greater reserve capacity because the forecasts of maximum brake loads are less reliable and also because they are more likely to be used while already hot from previous braking action.

Some linings will stand higher temperatures than others. Table 1 contains drum temperatures that apply to average specimens of the various types of linings. The data are suitable for design calculations. They should be confirmed by data from lining manufacturers in the final selection of the lining.

Many brake designs are based on empirical data. In the automobile industry for example, rules like 20 lb. of car weigh per sq. in. of lining are criticized because too few of the factors, such as speed, weight, deceleration, operating temperatures and others, are reflected in them. The rule of ½ hp. per sq. in. of brake lining contains more of the factors, but operating temperature is not among them. Some simple method of determining and evaluating the rates of heat generation and dissipation would be a great help in brake design.

Deceleration-Pedal-Pressure Tests

Automobile manufacturers buy brake linings on a performance basis. Fig. 8 is a typical performance specification. The

Table I—Drum Temperatures Suitable for Different Types of Linings

Type of lining	Drum temperature after normal brake service, deg. F.	Maximum drum temperature, deg. F.
Woven	300	500
Woven, heavy duty	450	750
Fabric	350	600
Dry mixed	450	750
Dry mixed blocks, heavy duty	700	1,100
Wire back, dough mixed	300	500
Extruded	400	700
Sheeter	400	700

Table II — Time in Seconds to Stop Inertia Dynamometer Wheel During Fade and Recovery Test

Stop No.	Fade, sec.	Recovery, sec.
1	8.2	13.6
2	9.4	12.6
3	11.0	14.0
4	13.0	16.0
5	14.0	19.0
6	13.2	21.2
7	14.0	19.0
8	14.0	18.0
9	14.0	20.0
10	14.6	20.2

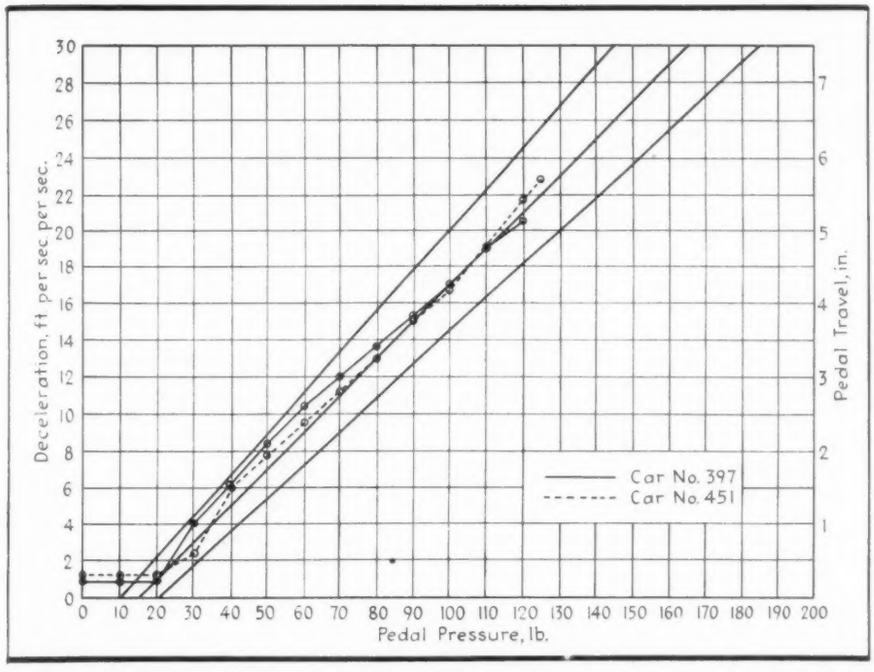


Fig. 8—Typical deceleration-pedal pressure performance of automobile brakes.

lines establish limits on the effectiveness of the entire braking system. The mean slope of the lines is determined by the coefficient of friction of the lining, and fluctuations in the coefficient of friction are a major cause for departures of test results from the mean slope. The two curves within the limit lines, Fig. 8, represent tests of specimens of the same lining in two passenger vehicles. The tests were made from an initial speed of 50 m.p.h. It is customary to make such tests from two and sometimes from three speeds.

The pedal pressure required to overcome the retracting springs in both cars was 20 lb. as indicated by the horizontal portions of the test curves, Fig. 8. The resultant deceleration from bearing friction, wind resistance and other items was slightly less than one ft. per sec. per sec. for the test in car No. 397 and a little more than one ft. per sec. per sec. for the other car.

Frequent attempts have been made to devise laboratory tests that would prove a brake lining for automobile service. Dynamometer tests provide a good index on lining performance; nevertheless the industry generally admits that road testing in test cars is still necessary.

Lining fade, its property to recover after fade, deceleration curves, lining build-up and wear tests are among the qualities that can be determined by inertia dynamometer tests. Table II contains data from a fade and recovery test. The fade test was conducted in the following manner: The inertia wheel, weighted proportionally to a fully loaded automobile, was brought up to a speed equivalent to 50 m.p.h. and then stopped by the brake. The time in sec. to stop the loaded rotating wheel was 8.2 sec. Twenty-five sec. later the wheel was stopped again from the same speed in 9.4 sec. and so on for ten stops. The lining was cold at the beginning of the test. The pressure on the brake was kept constant through out all stops so that the increase in the time of stopping the rotating wheel is indicative of lining fade.

The recovery test started 72 sec. after the tenth stop and from the same speed, i.e. the equivalent of 50 m.p.h. The time required to stop the wheel was 13.6 sec., which is less than 14.6 of the tenth stop and indicates a recovery of nearly 16 per cent of the frictional loss. Further recovery takes place during the second 72-sec. interval. As noted from the times in sec., Table II, the lining exhibits a wavering fade and recovery during the other eight stops.

Some investigators measure wear as diminished thickness of the lining before and after a specified number of stops; others by the loss of weight. Still others prefer to measure wear in units that are indicative of the amount of energy absorbed, such as oz. per million ft.-lb. or cu. in. per hp.-hr. Ease of measurement is one reason why the different methods are in use. The change in weight of a lining mounted in some brakes is readily obtained whereas dismounting of the lining might be required to measure the change in thickness. On the contrary the change in thickness is sometimes easier to get than the change in weight. Changes in weight can easily be converted into average changes in thickness if the density of the lining is known.

The effect of temperature on lining wear has already been mentioned. The metal against which the lining rubs is another factor that influences wear. Steel and cast iron normally cause about the same amount of wear of the friction element, although steel is more likely to score under severe service and as a consequence cause the lining to wear faster. On the other hand a comparison between the rates of lining wear against steel and aluminum show a marked difference. Bronze and other alloys also exhibit differences in rates of wear of the friction material.

Normally a friction material that wears little is desired. Yet, brake effectiveness may be impaired through a glazing of the friction surface if the lining does not wear at all. Fig. 9 is a wear curve obtained from dynamometer tests. The wear is nearly constant. The more rapid wear at the beginning of the test is characteristic of some linings.

EDITOR'S NOTE: The assistance and the contributions of matter for this article from more than thirty lining manufacturers, machine builders and makers of automobile and aircraft-wheel brakes are gratefully acknowledged.

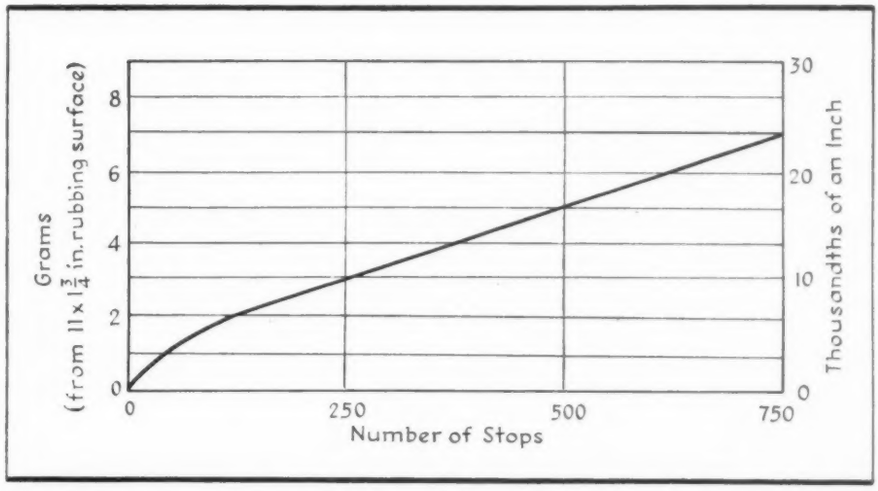


Fig. 9—Typical wear curve, data for which were taken from dynamometer tests of a wire-back medium-friction lining for automobile passenger cars.

Ductile Permanent Magnets Offer New Design Possibilities

J. H. GOSS
Engineer, Works Laboratory, General Electric Company

Properties of some ductile materials are presented; magnetic properties of magnet materials are compared; and factors to be considered in magnet design are explained with the aid of curves of the magnetic properties. Photographs show magnet parts and several novel mechanisms that have been fabricated from the ductile materials.

THE PROGRESS made in the development of permanent-magnet alloys during the past decade probably exceeds the total progress made between the discovery of natural magnets prior to the Christian Era and the beginning of the present decade. Fewer than a dozen alloys that were useful as permanent magnets were on the market a decade ago. More than 20 are available today. An increase in magnetic energy together with a wide choice of physical properties has also been achieved.

The magnetic energy values per unit weight of fourteen alloys are shown graphically in Fig. 1. Alnico 5, an alloy of aluminum, nickel, cobalt, copper, and iron, has an energy value over twenty times as great as that of carbon steel.

The newer materials are rapidly being specified on designs that were technically impossible with the older materials. They not only require less space and weigh less for an equal amount of magnetic energy but also cost less.

A mechanical linkage or gear arrangement, Fig. 2, for transmitting mechanical motion can be effected by magnetic means without the component parts of the mechanical system coming in contact. This allows the transmission of motion through sealed containers. Examples of other applications will be discussed later.

The factors in the choice of the proper magnetic material for a given application are confusing to the designer that may be unfamiliar with permanent-magnet design. This question might be asked: Why are so many different materials used instead of that one with the highest energy value? Although this article describes chiefly the properties of Cunife 31, Cunico and Silmanal, three new ductile permanent-magnet alloys, a brief explanation of the factors to be considered in choosing the optimum material for a given application is given first. Four important factors are:

1. The magnet must have sufficient developed length to supply the required magnetic potential to the air gap,

2. The cross-section of the magnet must be large enough to supply the necessary flux to the air gap,

3. The design, in order to use the material most efficiently, must operate at the optimum point on the demagnetization curve,

4. The magnet must meet reasonable economical considerations. Usual practice is to use the magnet with the lowest combined material and fabrication cost that will meet the space requirements.

Demagnetization curves for several materials and the energy value curves for these materials are illustrated in Fig. 3. The approximate length of the magnet required for a given application will vary inversely with the intercept on the horizontal axis of the demagnetization curve. The intercept is called the coercive force, H_c, and is a measure of the magnetic potential per unit of length. The higher the value of coercive force the shorter will be the length of magnet required. In Fig. 3 for the alloy Cunife 31, this value is 550 oersteds and the point is designated by C. To be strictly correct, the values of H that should be compared are those corresponding to the point of maximum energy value, i.e., 380 oersteds for Cunife.

The approximate cross-section of the magnet will vary inversely with the inter-

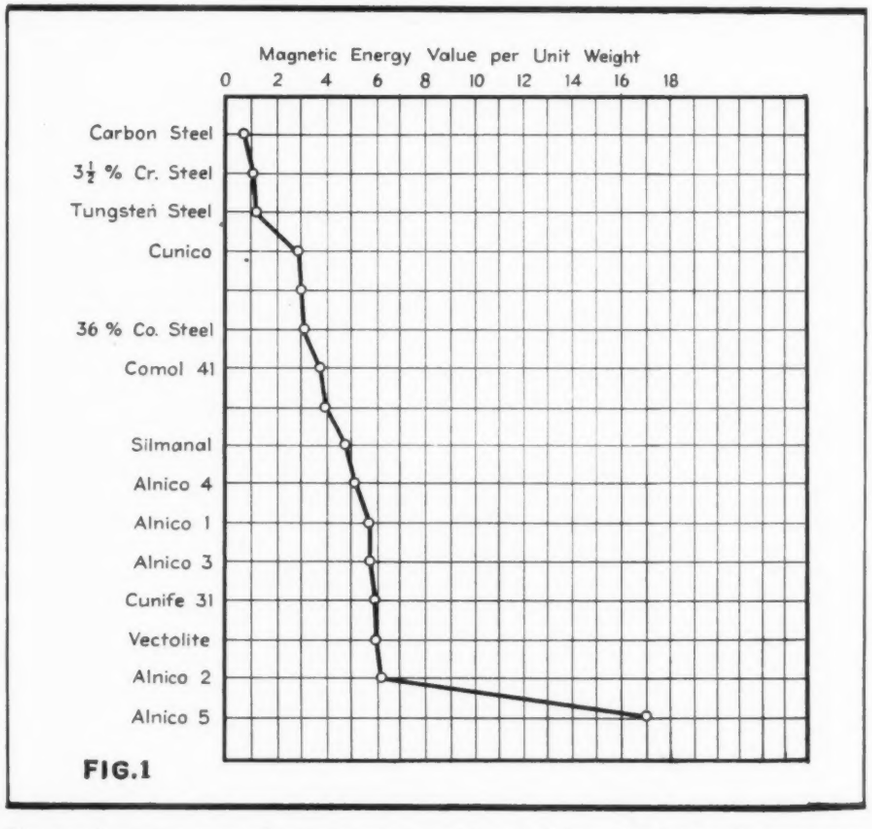


Fig. 1—A comparison of permanent-magnet materials on the basis of energy per unit weight.

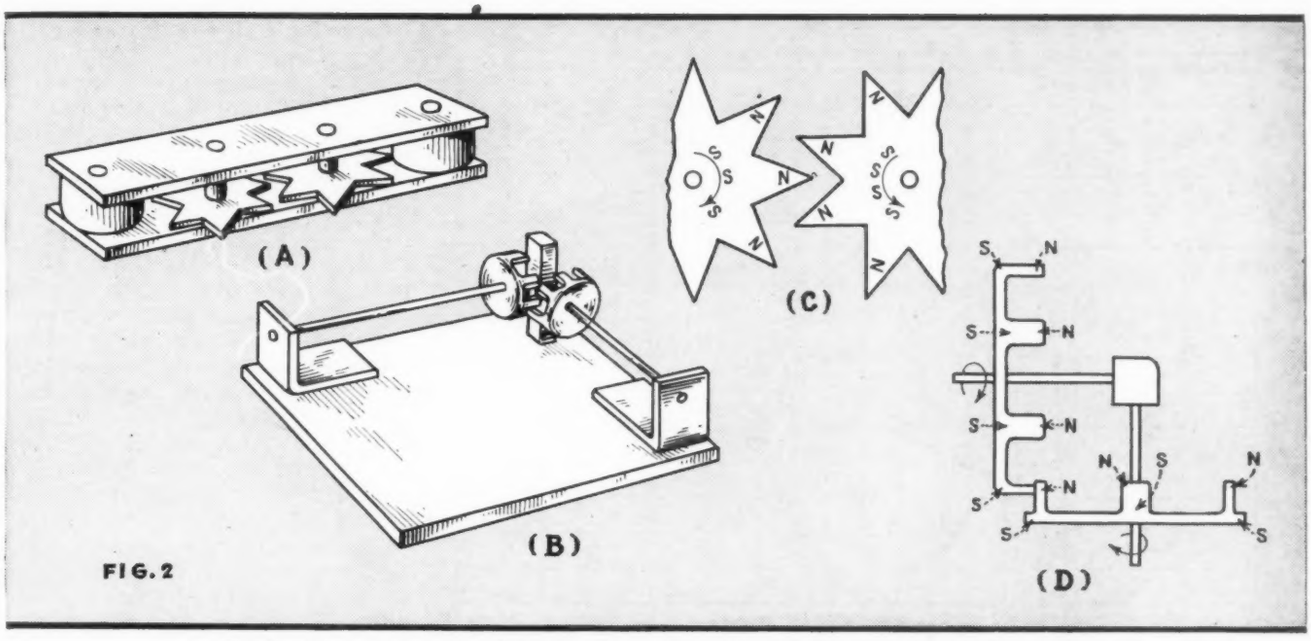
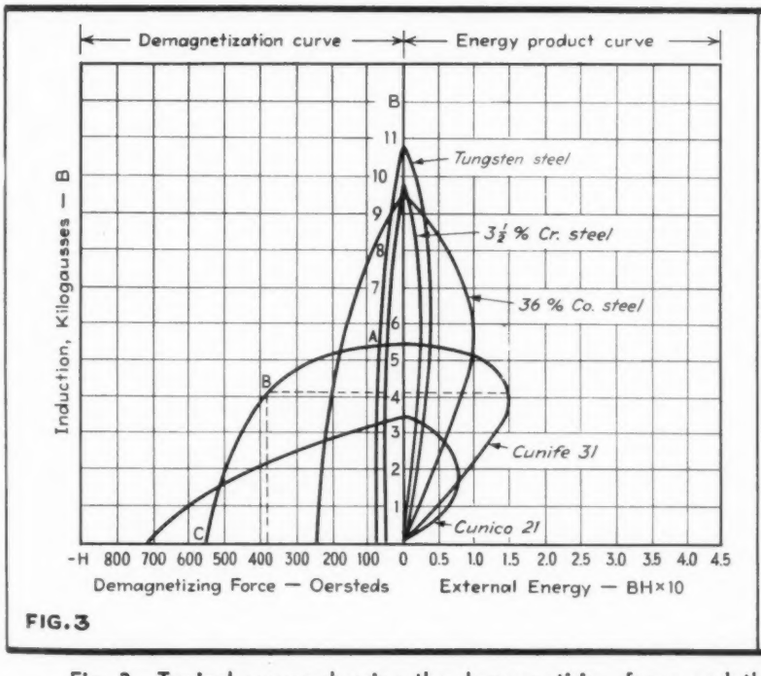


Fig.2—Magnetic gears of Cunico transmit motion without contact of the teeth.



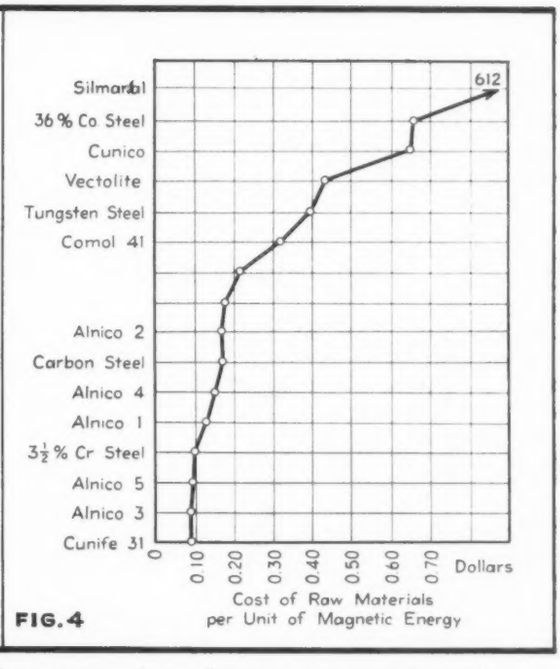


Fig. 3—Typical curves showing the demagnetizing force and the energy values of some permanent-magnet materials. Fig. 4—The relative raw material costs of permanent-magnet alloys per unit of magnetic energy.

cept on the vertical axis, which is called the residual induction, B_r. The higher the hesidual induction the smaller will be the cross-section required. This is point A in Fig. 3. for Cunife 31. Here, also, the correct value of B to be compared corresponds to the B for maximum energy value or 4050 gausses.

To make the most efficient utilization of the material, the magnet should operate at all cross-sections at the value of induction corresponding to the maximum energy value, for example B for Cunife 31 in Fig. 3. In practice this state of operation is seldom attained exactly, but it is a good criterion to strive for in laying out a design.

The foregoing considerations determine the materials that could be used and are the basis for arriving at the required dimensions. The balance of the decision rests on over-all economic considerations. The costs of using the alloys in permanent magnets cannot be decided from a comparison of the costs of the raw materials alone because other costs incidental to manufacture are often large in proportion. Fig. 4 indicates the spread in raw material costs per unit of magnetic energy for various permanent magnet materials, but this information should be used to supplement other items in arriving at the over-all cost.

Two great limitations on the application of permanent magnets in the past have been:

1. The low energy values of the alloys that could be fabricated in the ductile state.

2. The difficulties of fabrication of the high energy alloys such as the Alnicos because of their hard and brittle structures.

A notable exception are the Alnicos that can be made by the powdered metallurgy process, which yields small magnets of shapes that permit pressing at low unit

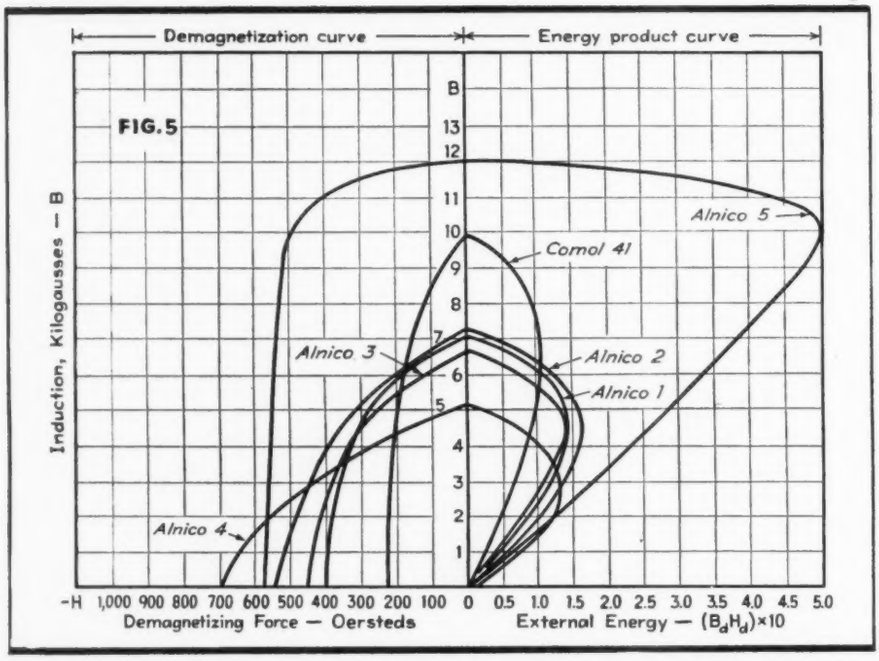


Fig. 5—Typical curves showing the damagnetizing force and the energy values of Alnico magnet materials for comparison with the ductile material curves.

cost and to close dimensions. Fig. 5 shows the demagnetization and energy curves for the five Alnico materials. All of them are hard and brittle alloys.

Cunife 31 and Cunico are ductile materials. Their magnetic characteristics are shown in Fig. 3. The constituents of Cunife 31 are Cu 60, Ni 20, and Fe 20 percent. A typical Cunico composition is Cu 50, Ni 21, and Co 29 percent.

Wire drawn from Cunife 31, whose magnetic properties compare favorably with some of the Alnico materials, is shown in Fig. 6. The wire shown is 0.062 in. diameter, but wire can be drawn as small as 0.003 in. in diameter. It can be readily worked in a wire bending machine or bent into complicated shapes. The material can be drawn and heat-treated. The electrical conductivity of Cunife is approximately nine percent of the copper content. It is approximately seven percent of the copper content for Cunico.

A variety of parts made from wire, sheet, and rod stock by punching, forming, and screw machine operations are illustrated in Fig. 7. The center washer is two inches in diameter, which gives an index of the size of these parts. Table I contains additional information on the properties of Cunife and Cunico for comparison with other magnet materials.

Cunico rod stock can be machined on a screw machine into screws of different sizes, including fine threaded screws. Small screws can be threaded into larger parts to make up a balanced magnet assembly. Screws can be machined from rod stock which is 5/8 in. in diameter. See Table I for other information about Cunico.

A third material of the ductile class that has unusual properties is an alloy called Silmanal, containing Ag 86, Al 5, and Mn 9 percent. This non-ferrous alloy has a coercive force, H_{ci} (intrinsic), of 6000 oersteds and a residual induction, B_r of 550 gausses. This material requires an extremely short length of magnet for a given air gap as compared with the materials previously discussed. The low induction requires a large cross-sectional area. The material can be drawn cold into wire or made into rod or sheet form. It is readily machinable, resistant to demagnetization, and may be subjected to heavy alternating current fields without change.

A novel example of a use of Silmanal is shown in Fig. 8. A compass needle of this alloy can be magnetized across its thickness to make use of the high magnetic potential per unit length, in contrast to a normal compass, which is always magnetized along its length. The compass points east and west instead of north and south.

The gear trains, Fig. 2, made from Cunico have the gears magnetized in such a manner that like poles are always present and when one gear is driven, the mating

Fig. 6—Cunife 31 wire is ductile and can be drawn as small as 0.003 in. in diameter.

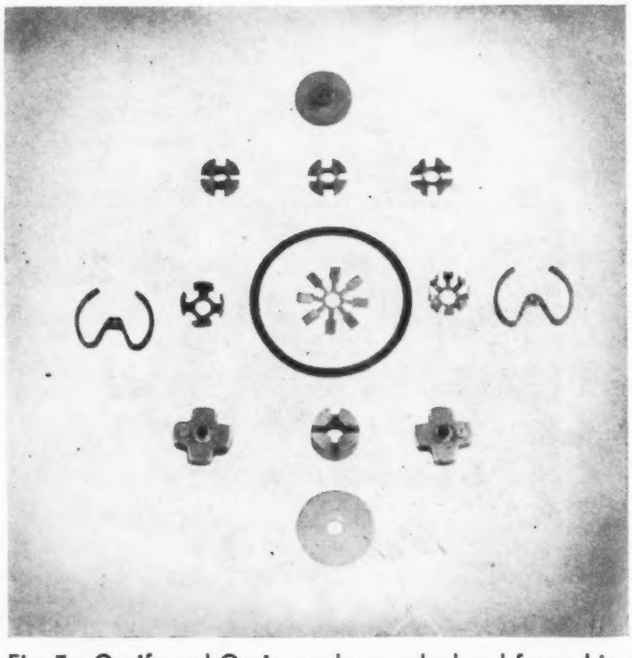


Fig. 7—Cunife and Cunio can be punched and formed in a wide variety of sizes and shapes.

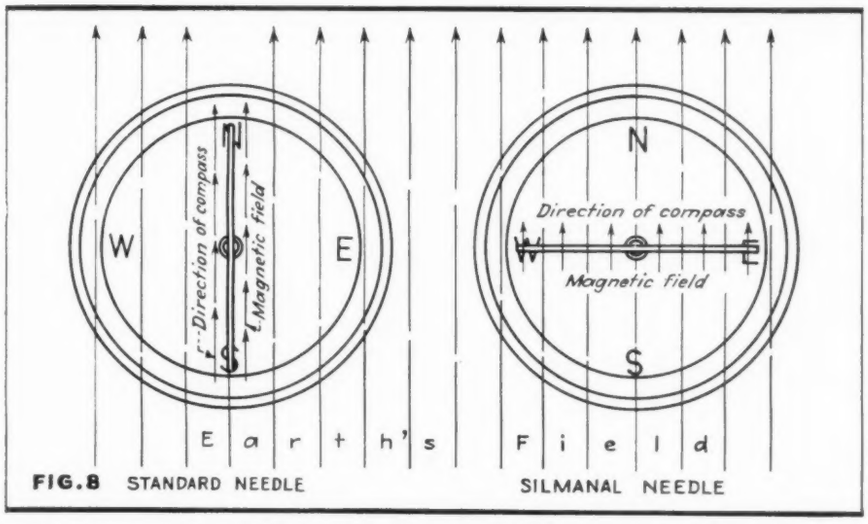


Fig. 8—A compass needle of Silmanal, magnetized across its thickness, is compared with a standard compass needle, which is magnetized along its length.

gear is forced to turn by magnetic repulsion without the teeth actually coming into contact.

An application of magnetic attraction is shown in Fig. 9, a gasoline gage transmitter and float assembly for aircraft. As the tank must be sealed, the position of the float is transmitted magnetically through a solid aluminum wall to drive the transmitter shaft. This transmitter in turn operates an indicating instrument on the pilot's instrument panel showing the fuel level in the tank at all times.

These are but a few examples of possible applications of the new ductile materials. They give, however, some indication of the scope the new materials offer to designers of permanent magnets. A wider use of these materials is expected as designers learn more about them and study possible applications where permanent magnets have not been practical before.

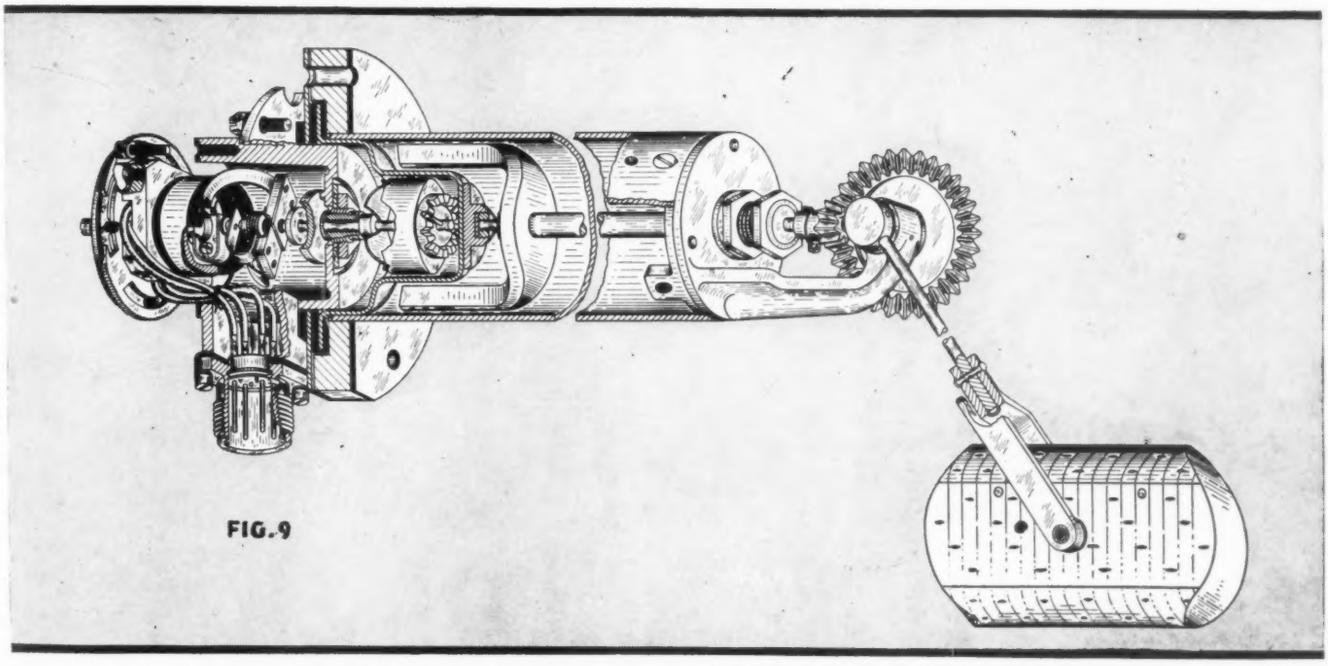


Fig. 9—Liquid level within a sealed gasoline tank on aircraft is transferred from a float assembly by magnetic attraction so as to actuate a selsyn transmitter outside the tank.

Table I—Permanent Magnet Materials

ALLOY DESIGNATION	Coercive Force, Oersteds	Residual Induction, gausses	Density, g. per c.c.	Machanical Properties	Method of Fabrication	Tensile Strength, lb. per sq. in.
Chrome steel	63	9,000	8.20	Hard, strong	Hot forge, cast machine	
Cobalt steel	240	9,500	8.16	Hard, strong	Hot forge, machine, cast	
Cunife	550	5,400	8.62	Ductile	Cold roll, machine punch	120,000
Alnico V	525	12,500	7.30	Hard, brittle	Cast grind	5,450
Cunico	710	3,400	8.30	Ductile	Cast, cold roll, machine	110,000
Silmanal	6,000*	550	9.00	Ductile	Cold roll, machine punch	.....

* Demagnetizing force required to reduce the intrinsic induction to zero, usually denoted by jH_c

Methods of Actuating Brakes—

Satisfactory braking depends, in addition to other factors, on speedy and reliable actuating mechanisms. These may be of a variety of types, some of which, utilizing electricity, magnetism and vacuum as a source of power, are described and illustrated below

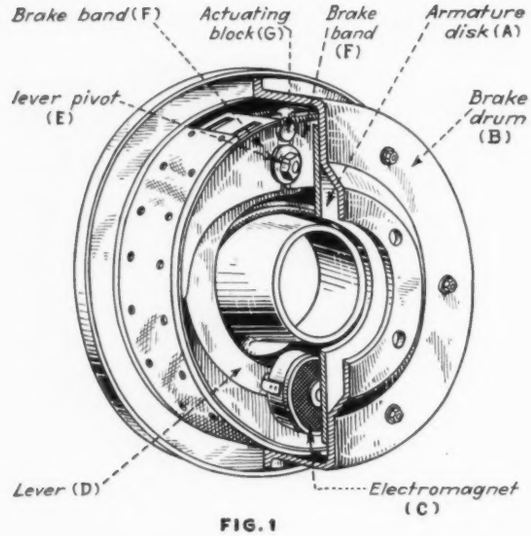


FIG. 1

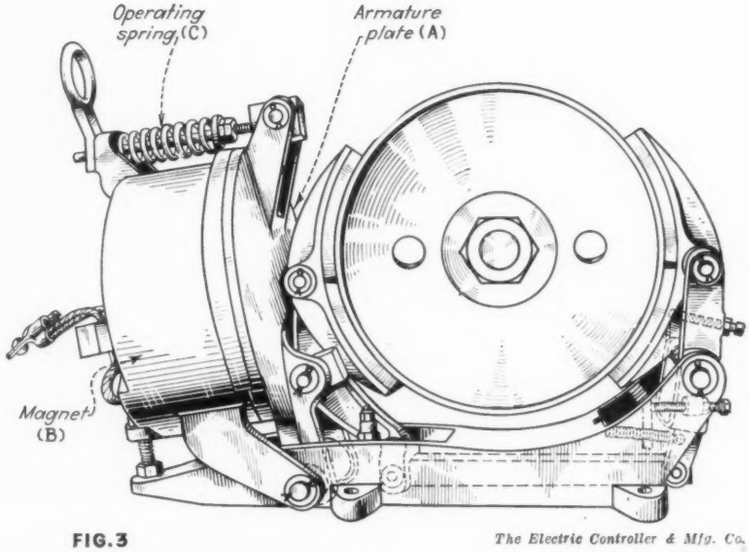


FIG. 3

The Electric Controller & Mfg. Co.

Fig. 1—The armature disk (*A*) is secured to and rotates with the brake drum (*B*). The electro-magnet (*C*) is supported on the end of lever (*D*), and is always in light contact with the armature disk. Lever pivot (*E*) is at a point between the ends of the brake band (*F*). The electrical input is varied through a controller. As the current flows through the electromagnet, the energized magnet is attracted to the armature disk, which is rotating with the brake drum. The frictional force developed by the magnet pressing against the armature disk draws the lever in the direction in which the brake drum is rotating. This movement of the lever changes the position of the actuating block (*G*), thereby spreading the brake band so that it presses against the drum. A small flow of current from the controller gives a light braking action. Heavier flows of current permit stronger braking.

Fig. 2—The vertically mounted torque motor (*A*) operates a simple anti-friction ball jack. When the power is applied to the motor of the brake, the motor shaft turns and lifts the operating lever (*B*) to release the brake. When the brake is fully released, the torque motor is stalled across the line. When power is interrupted, the torque motor is de-energized and the heavy compression spring (*C*) applies the brake.

Fig. 3—The armature plate (*A*) is held away from the magnet (*B*) by the operating spring (*C*) which provides the necessary pressure between the brake shoes and the wheel. When the magnet is energized, the armature plate is pulled up to the magnet against the spring pressure, which releases the brake. The magnet remains stationary.

Fig. 4—The plunger action of the solenoid (*A*) releases the brake. The brake is applied, upon power failure or interruption through a pilot device, by a strong spring action (*B*).

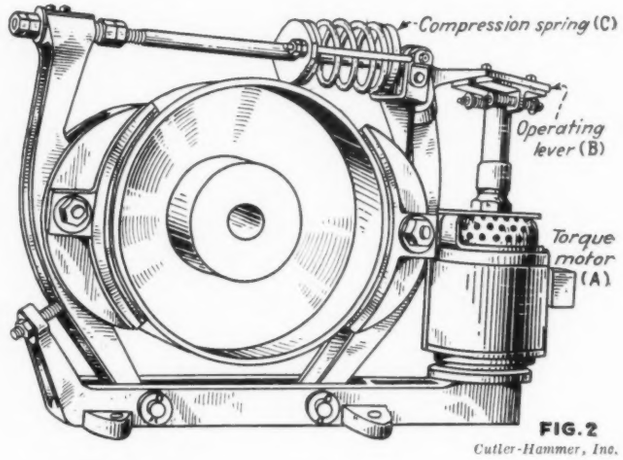


FIG. 2

Cutler-Hammer, Inc.

Fig. 5—The vacuum power cylinder (*A*) is under control by the hydraulic pressure from the master cylinder (*C*). Force from the vacuum power cylinder piston is applied through the piston rod to the piston of the hydraulic cylinder. This force is transmitted directly to the wheel cylinders through the hydraulic lines. The vacuum power cylinder piston-rod bears against a valve in the hydraulic cylinder piston. This valve is open when the vacuum power cylinder is in released position, allowing fluid to flow through a passage in the hydraulic piston. The valve remains open until hydraulic line pressure builds up to the point of opening the control valve (*B*), in response to which the power cylinder piston moves into applied position.

Fig. 6—When the brake pedal is depressed, hydraulic liquid is forced from (*A*) through the hollow control piston (*B*) to the brake line (*C*), which moves the brake shoes into contact with

Electric, Magnetic and Vacuum

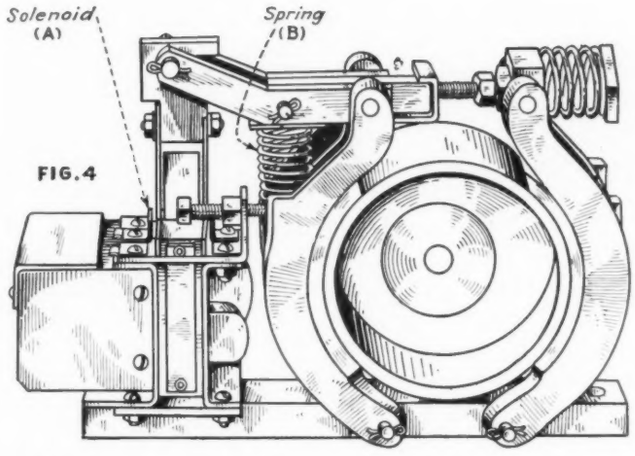


FIG. 4

Cutler-Hammer, Inc.

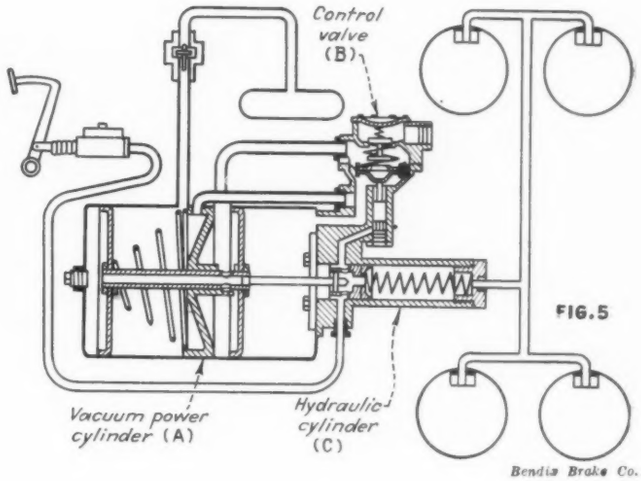


FIG. 5

Bendix Brake Co.

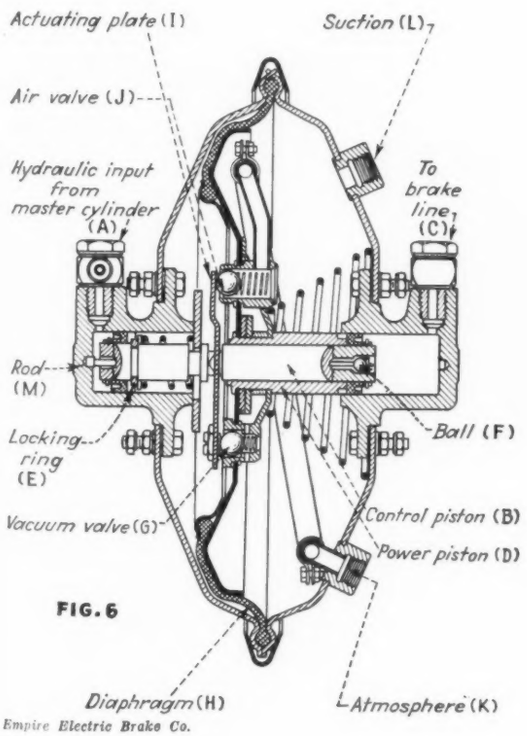


FIG. 6

Empire Electric Brake Co.

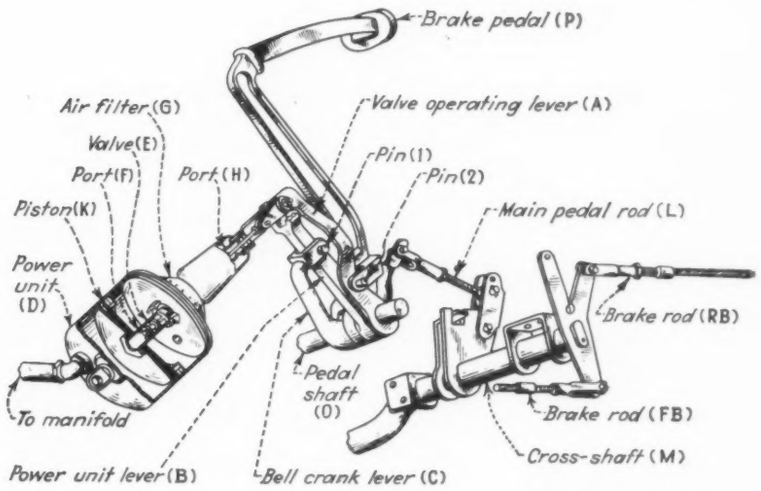


FIG. 7

Bendix Brake Co.

the brake drum. As the pedal is depressed further, the control piston (*B*) running through the center of power piston (*D*) is forced to move toward the secondary end by the increasing pressure of the liquid against the primary end of the piston. The primary end of the piston has a larger surface than the secondary end because of the locking ring (*E*) back of the piston cup. As the piston moves, the ball (*F*) is free to seal, permitting the flow of fluid from points (*A*) to (*C*), but checking the flow in the opposite direction. Simultaneously, the vacuum valve (*G*) connecting the two sides of the rubber diaphragm (*H*) is forced to close by the movement of the valve actuating plate (*I*) so that vacuum can no longer pass from one side of the diaphragm to the other. When the brake pedal is depressed slightly further and the hydraulic pressure is increased accordingly, the resulting movement of the control piston (*B*) causes the actuating plate (*I*) to open air valve (*J*) so that air is admitted from the atmosphere (*K*) to the pressure side of the diaphragm while the vacuum on the other side is maintained through the continuous suction (*L*) from the intake manifold. The admission of air into the booster is modulated to apply the brakes with a force proportional to the pedal pressure. As the brake pedal is further depressed, air continues to flow into the pressure side of the diaphragm, reaching atmospheric pressure when full force has been expended on the pedal. The vacuum-hydraulic power is then fully applied. The rod (*M*) in control piston (*B*) meets ball (*F*) when the brake pedal is fully released.

Fig. 7—As the brake pedal (*P*) is depressed, the initial travel operates the internal valve (*E*) within the power unit (*D*) through the valve operating lever (*A*). Atmosphere is admitted through port (*F*), first passing through air filter (*G*) and past (*H*) to the rear chamber of the cylinder. Atmospheric pressure forces the piston (*K*) forward, actuating power unit lever (*B*) which in turn relays the power through bell crank lever (*C*) to the main pedal rod (*L*) connected with the cross-shaft (*M*). Due to the fact that the power unit lever (*B*) has a clearance around the pedal shaft (*O*) and is pivoted at pin (1) a certain proportion of the power derived from the cylinder is balanced against the brake pedal (*P*) through pin (2). Cables (*RB*) and (*FB*) transmit the power from cross shaft (*M*) to the shoes and drums.

ENGINEERING ABSTRACTS

FOREIGN ARTICLES—TECHNICAL SOCIETY PAPERS

Brake Linings

Foreign Abstract, condensed from an article by G. S. Gidvani in *Plastics* (London), November, 1945, page 541.

RECENT ADVANCES in brake linings have resulted from treating the asbestos with a number of impregnating compounds. These can be classified as follows: drying oils, resins, bitumens and rubber compounds.

Drying Oils: Linseed oil is a common binder for brake linings. It is used either uncompounded or in mixtures with other materials. Other oils used are tung, poppy seed, hemp seed, walnut, sufflour and sunflower. Oils are dried during the manufacture of brake linings by baking them at a relatively high temperature. Oxidizing accelerators, added to reduce drying time, are litharge, manganese-oxide, linoleates, naphthonates and others. Linseed oil is generally employed to give body to the woven lining, but it tends to dry at the surface without hardening at the center. If it is used alone, curing is carried out in the presence of nitrogen or carbon-dioxide. This material, however, is usually combined with China wood oil. Both linseed and tung oil are usually blended with resins and bitumens in the form of baking varnishes.

Resins: Synthetic thermosetting resins resulting from the reaction of formaldehyde with either phenols or urea have frequently been suggested as binders for brake linings. Casein-formaldehyde and glyptal are in limited use in England. Natural resins are not used to any extent. Phenolic resins, particularly formaldehydes or cresylics, are far more popular and are applied either as viscous liquids or powders. Urea and casein resins are usually applied in aqueous solutions.

Bitumens: For brake linings, gilsonite is the most widely used natural asphalt. It is applied in solutions of gasoline, alcohol, heavy oils or carbon bisulphite. Care must be taken when this material is deposited on the brake lining, as it tends to remain on the surface, thereby giving rise to non-uniform friction characteristics. When high temperatures are produced by repeated sudden stops, gilsonite becomes soft and sticks to the drum, if the brake is set while the drum is still hot. By heating this material with sulphur at 482-572 deg. F., it becomes infusible.

Asphalts have both waterproofing and frictional properties. Tars give color and body to the impregnating liquid. Among the tars, water-gas tar is most commonly used. It contains oils, but it is free from carbon and hardens progressively at elevated temperatures, throughout its braking life. Coal tar has a large quantity of free carbon, becomes sticky at high temperatures and gives higher friction values, under these conditions. All bitumens may either be used unmixed or combined with resins, oils or rubber compounds.

Rubber Compounds: When rubber is heat-treated it becomes increasingly plastic, until it flows freely and penetrates, at least partly, into the fibers of the asbestos fabric. Complete impregnation can be achieved under steam-heated rolls. Rubber, being thermoplastic originally, cannot be used in brake lining unless vulcanized, after treatment, with sulphur and other materials. Vulcanized rubber compounds have excellent braking properties and most U. S. brake linings contain a portion of these materials. Vulcanization of rubber is slow without organic or inorganic accelerators. Fillers such as carbon black, zinc oxide and others are commonly employed.

There are three types of brake linings: woven, molded asbestos fabric and molded asbestos-fiber. Woven linings are made from Chrysotile asbestos, long-stapled cotton and thin brass or lead and zinc alloyed wires. While there is considerable patent literature regarding the weaving of these materials, their composition generally varies within the following limits; asbestos, 40-65 percent; cotton, 5-20 percent; wire, 20-40 percent.

The fabric is subsequently impregnated with 5 to 15 percent binder. Type, quantity and application of binder determines the quality and wear resistance of the brake lining. The complete penetration of binder into the fabric is of the utmost importance.

The impregnation of the fabric with the binder takes place in a dipping tank, excess fluid being removed by a scraper. The fabric is dried at about 400 deg. F. The fabric can also be impregnated after evacuation. Binder can be dripped on the fabric, or is applied in powder form to the asbestos and cotton fibers after they are carded. When the fibers are woven and heat treated, the binder plasticizes and flows into the webs of the material. In the most recent processes the yarn is coated with the binder and then woven into the fabric.

Calendering performed under steam-heated rolls, enhances the life of the lining, as it increases the density and wear-resistance. Finally, linings are stenciled and cut to size.

In molded fabric linings, asbestos-cotton-wire woven fabric is impregnated exactly as before with the woven linings but less binder is applied—usually only about 2-5 percent of the weight of the fabric. This impregnation with drying oils and bituminous materials is supposed to waterproof the fabric. The dried waterproof fabric is then coated with friction compounds on a heavy calendering machine. Sometimes abrasive materials such as carborundum or iron oxide to increase friction, and materials such as graphite or mica are added, to lower friction. The friction compound is pressed into the fabric, which becomes thoroughly coated. Thickness of the deposit is controllable. The cloth is finally cut into strips of the required width and rolled on spools.

The lining is then pre-molded into the desired size and shape by a folding process, in which the fabric is doubled, curled or looped. Here it is compressed under heat until completely cured. The folds run parallel to the thickness or wearing surface in a molded lining, but in a loop-folded lining they run opposite to the thickness.

Pre-molding may also be performed by a rolling process, in which the calender fabric is wound on a hollow mandrel of the desired curvature. Heat-treatment softens the compound and binds the fabric. The brake lining is either fully cured and then cut to size, or first cut and then cured. Another method consists of tightly rolling up the fabric to the desired size and then curing in a cylindrical mold.

Laminated linings can also be pre-molded on a calendering or a laminating machine, in which calendered and bonding-cement coated fabric layers are compressed to the desired shape and then cured. Laminations can combine different fabrics and binders for special effects.

In molded fiber linings, the asbestos fibers are not woven, but mixed directly with the friction compound in a ball mill, or by repeated sifting. The mixture is then extruded or rolled hot and a continuous strip is produced, which is finally hot-pressed hydraulically. Material is frequently wire-backed. Mixing is an important step in the production of these linings. Wet mixings make use of volatile solvents under an inclosed dough mixer to produce stiff dough-like masses. Non-volatile "wet" solvents employ a pulp-beater type mixer with subsequent filtration or centrifugation.

Rubber compounds and sulphur are us-

ually mixed with the asbestos fibers on hot rolls, as they are used in the rubber industry. Rubber added to asbestos stiffens to such an extent that softeners, such as fatty acids, waxes, oils, must be added. Mixed compounds are formed into sheet, calendered and vulcanized. Rubber alone is not suited for brake linings, but is compounded with asbestos, steel or mineral wool, cotton, flax, carbon black and zinc oxide.

Wet mixing processes produce linings with fibers lying in all directions; the sheeting process makes them unidirectional. Laminations are produced from these sheets for special braking effects.

Temperatures up to 500 deg. F. may become common in the future, and, under repeated breaking, may go up to 800 deg. F. The normal rate of work for ordinary brake linings is 13,200 ft.-lb. per. sq. in. per min. On trucks or buses it averages 49,000 ft. lb. per sq. in. per min. In a passenger car, loading is limited to 10-25 lb. per sq. in. and in trucks and buses it can go up to 300 lb. per sq. in. For heavy-duty work friction blocks instead of ordinary linings are employed. Woven linings are safe up to 340 deg. F., with breakdown at 500 deg. C. Molded fabric and fiber linings are used for greater rubbing velocities, higher temperatures and pressures. Friction blocks are made by die-pressing the impregnated fibers, using the same compositions as in molded fibers, the main difference being that of shape and size, and manner of attachment to the brake shoe.

A New French Locomotive

Foreign abstract, condensed from *The Engineer*, **Aug. 3, 1945, page 96.**

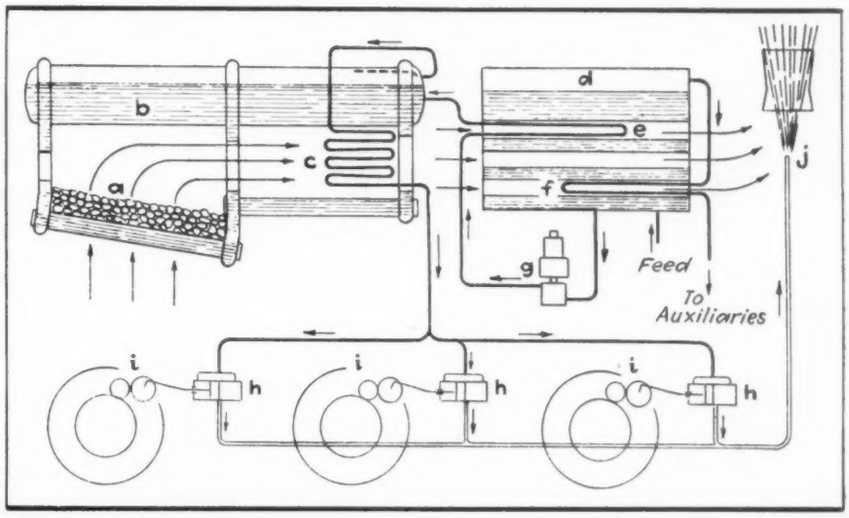
A RADICAL DEVELOPMENT in locomotive design is presented by the new French 4-6-4 multi-engined locomotive which was developed between 1936 and 1939. The war intervening, it was not put into service until 1943. The three driving axles of the engine are actuated by six separate 3-cylinder reciprocating engines, powered by a dual pressure boiler. The steam and gas flow diagram shows the arrangement; the fire box is in the high-pressure part of the boiler, which is of tubular design. Passing the superheater c, the hot gases enter the smoke tubes of a low-pressure boiler of normal locomotive design and are expelled by the hot blast. In the upper tubes are arranged feed-heater elements e for the high-pressure boiler and in the lower tubes there are the superheater elements f for the low pressure steam. The six engines *h*, one at each end of the three driving axles, are fed with high-pressure steam through cam-operated poppet valves. The cylinders exhaust on a central belt. At about 70 m.p.h., they make 800 r.p.m. and at 80 m.p.h., 1,000 r.p.m. The engines are coupled to the driving axle by reducing gear.

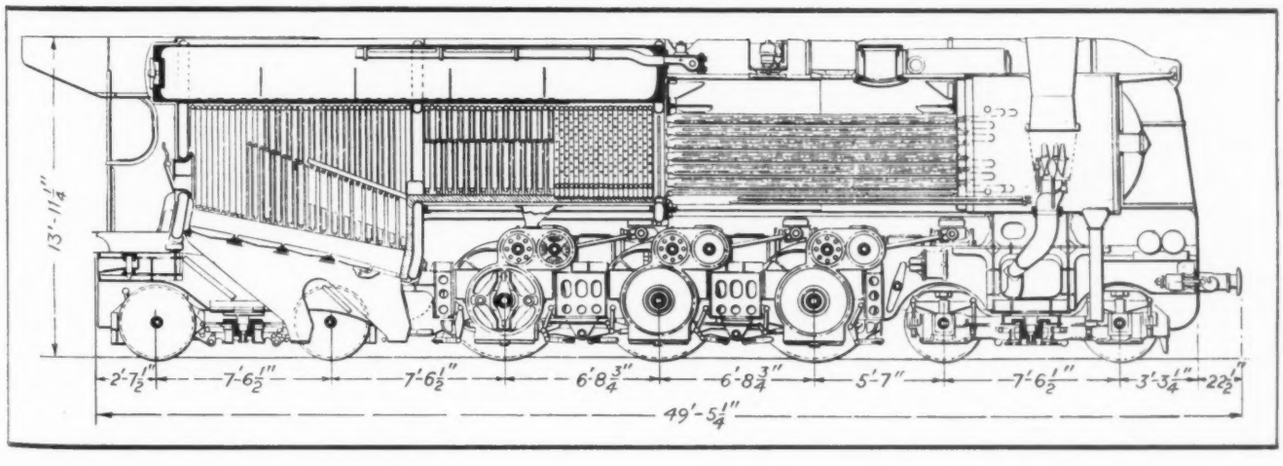
The high-pressure boiler is composed entirely of tubes and a chromium-molybdenum drum which is 27.6 in. in dia. The walls of the fire box are tubular and are made air-tight by a packing of refractory material with an asbestos mattress to cover. The special superheater with tubular elements of 1.30 to 1.57 in. dia. unites two upper collectors for saturated and two lower collectors for superheated steam. Collectors serve motors on either side of the engine.

The low-pressure boiler which primarily preheats the feed water, has no outstanding features. Salts left in the water after trisodium phosphate treatment are here deposited so that pure water is delivered to the high-pressure boiler. The two high-pressure Knorr-type feed pumps have two steam cylinders, each working compound driving a single water cylinder. Special devices maintain the proper balance between the two boilers.

Particulars of Locomotive

Total length over tender buffers	82 ft. 0.3 in.
Rigid Wheel base	13 ft. 5.4 in.
Diameter of driving wheels	5 ft. 1 in.
Weight in running order	139 tons
High-pressure boiler—	
Working pressure	60 atmos.
Volume	124 cu. ft.
Grate area	37 sq. ft.
Heating surface	473 sq. ft.
Superheater surface	376 sq. ft.
Economiser surface	1,076 sq. ft.
Low-pressure Boiler—	
Working pressure	20 atmos.
Heating surface	1,352 sq. ft.
Superheater surface	484 sq. ft.
Motors—	
Number (three cylinders each)	Six
Bore and stroke	5.9x10 in.
U. S. horsepower per engine	690





Small Flexible Couplings

From "Small Flexible Couplings" by William A. Willis, communication and navigation engineering, Bendix Radio Division of Bendix Aviation Corporation in Bendix Radio Engineering, October 1945, page 12.

IN SMALL PRECISION MECHANISMS and those running at relatively high speed or under heavy load the axial misalignment, angular misalignment, or a combination of both, creates stress reversals that greatly decrease accurate life or may permanently ruin the mechanism. The numerous types of small flexible couplings to compensate for shaft misalignment, can all be analyzed as corresponding to one of the three general types (1) the single pin and slot type, (2) the Oldham type or double pin and slot type, (3) the Hooke type coupling.

The single pin and slot type coupling compensates for any of the three basic types of misalignment, although during a complete revolution the angular velocity ratio is not constant throughout. If the shaft misalignment is designated as C and the pin ratio as R, the angular velocity variation will range from a minimum of R/(R+C) to a maximum of R/(R-C).

Th Oldham type coupling is used where the shafts are close together and a constant velocity ratio of unity is necessary to compensate for axial misalignment. It will also compensate for a slight amount of angular misalignment. In place of the conventional design of Oldham coupling, the sliding fits can be replaced with pins and slots, the pins being positioned at the ends of two opposite in-line crank arms on each of the coupling parts that are fastened to the respective shafts. The "sandwich" member consists of a four-armed disk with axial slots extending in from the ends of the arms, in which slots the pins of the engaging elements can move radially.

The Oldham type finds many applications mostly in precision instruments because theoretically it maintains constant angular velocity ratio unity throughout the revolution.

The Hooke coupling, commonly known as universal joints, finds its greatest applications in machine tools and automotive equipment. The angular velocity ratio of the shafts connected by this type of coupling is similar to that obtained with a single pin and slot type coupling. For an angular misalignment of 25 deg. the angular velocity ratio will range from about 1.00 to 0.92. For angular misalignment of 5 deg. the variation in angular velocity ratio is of the order of only about 1 percent. By placing two universal type couplings in series the variations in angular velocity ratio compensate each other and constant angular velocity is maintained throughout the revolution of the shafts. In this arrangement it is essential that the couplings are connected so that the intermediate connecting shaft makes the same angle with both the driver and the driven shaft.

The original article contains fourteen figures including charts that give the angular velocity ratio curve for the single pin and slot type coupling and the Hooke type.

Loading Capacity of Porous Bearings

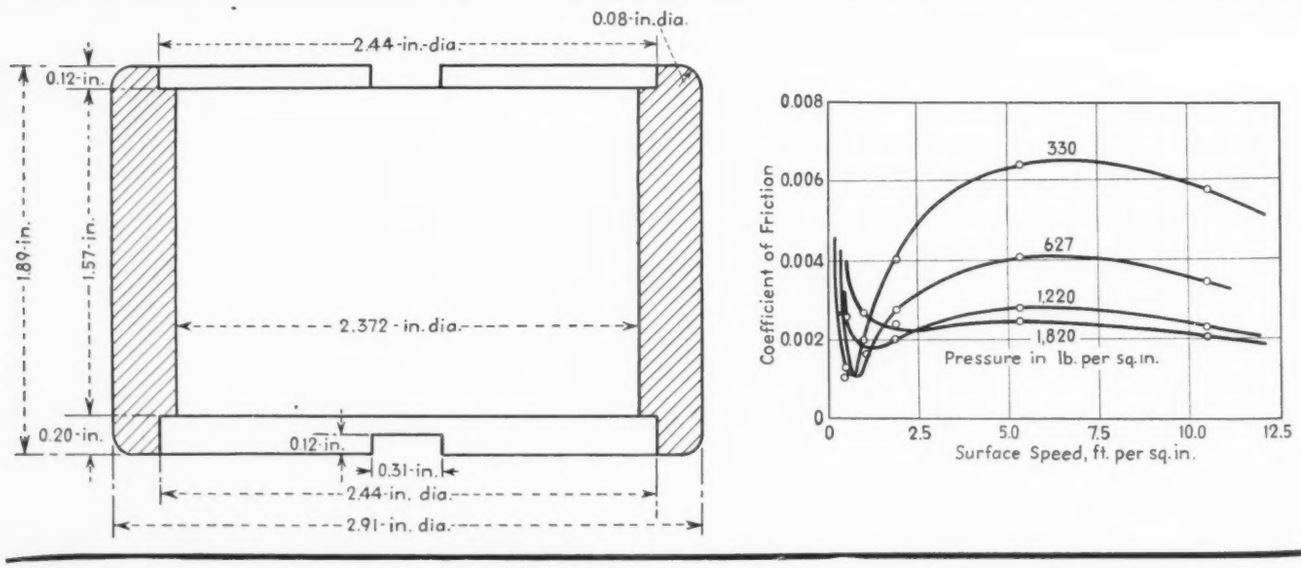
Foreign Abstract, condensed from an article by E. Heidebrock in *V. D. I. Zeitschrift*, (Germany) April 22, 1944, page 205.

SELF-LUBRICATING BEARINGS, employed where supply of lubricant is difficult to maintain, are usually designed into the iron form liners made by powder metullurgy methods. The optimum application range of these parts has an upper limit of about 17 ft. per sec. surface speed. At higher speeds sintered iron bearings compare favorably with average quality solid metal bearings only if there is a constant supply of lubricant, as in conventional bearings. The value of these bearings lies in extended operations with low friction and without external oil supply, provided loads are limited and operating temperatures low.

The theory of lubrication in these bearings is still unclear. However, there is always a strong molecular layer of lubricant on the liner surface which cannot sustain heavy loads, high speeds or temperatures. The structure of these liners is of considerable influence on these conditions.

Tests were performed on a special machine under equilibrium conditions, on journals of 2.362 in. dia. and 1.575 in. width, made from a 0.60 percent C steel. Clearance between journal and bearing was 0.010 in. Maximum loads supported by the bearing were established for different speeds. Limits were defined as maximum loads that can be carried without sacrificing performance or exceeding an oil film temperature of 176 deg. F. These conditions keep wear and contact friction at a level where they cannot be measured.

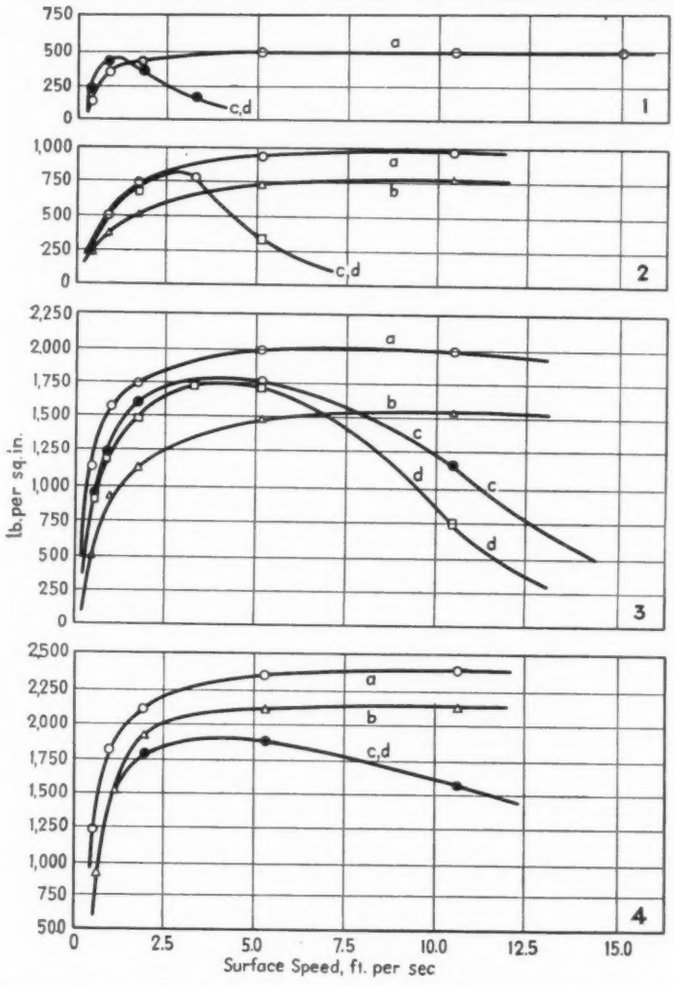
All tests were begun under a continuous lubrication run-in period, in which oil was supplied at 68 deg. F. and 1 atm. pressure; oil rated 5 deg. Engler at 122 deg. F. Drip feed operated at about 10 drops per. min. and oil supply was interrupted at the end of the test run. The temperature of the oil

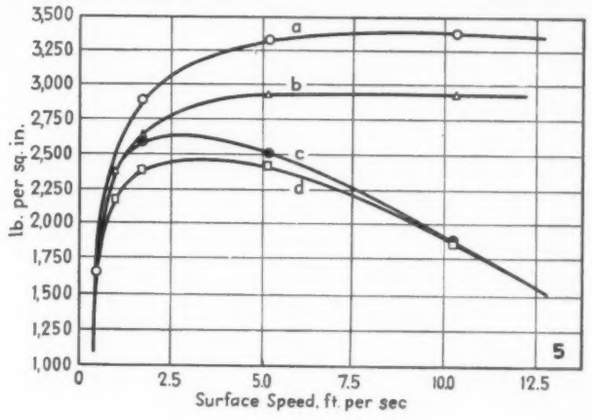


(Left) Design of porous iron bearings as tested. (Right) Coefficient of friction vs. bearing load and surface speed of journal.

film was determined by a thermocouple at a point ahead of the pressure apex. Speed of shaft in r.p.m. and torsion on linear were also taken to determine friction. When friction coefficients are plotted against peripheral speeds for different bearing loads curves closely follow those established for hydrodynamic friction. Throughout this test bearing temperatures were kept low and hardly exceeded 140 deg. F.

These tests show that optimum efficiency lies in a balance between fineness of grain and porosity. Under this condition bearing characteristics are excellent from the point of view of high load carrying capacity and of operational safety under emergency conditions, such as an interruption in the lubricant supply.





(a) Bearing is continuously lubricated after a prolonged running-in period. (b) Bearing is continuously lubricated after a 3-hr. running-in period. (c) Bearing is lubricated by drip oiling. (d) Bearing runs without external supply of lubricant.

Fig. No.	Powder *	Grain Size	Spec. Grav.	Finish on
1	M²	coarse	5.8	lathe
2	C	special	5.1	lathe
3	M	fine	5.8	lathe
4	M	fine	5.8	lathe
5	M	medium	6.4	broach

* produced M-mechanically ²width lead addition C-chemically

Relationship between pressure and surface speed of porous iron bearings made from different powders.

Silicones Outstanding Properties

From "Silicones—Miracle of Molecule Engineering" in Westinghouse Engineer, September 1945, page 130.

SILICONE RESINS, possessing the desired properties for high-temperature electrical insulation, can be applied in liquid form to fabrics of fiber glass or asbestos and upon baking forms a water repellent, heat resisting solid. Other silicone resins have been developed for enameling magnet wire, bonding fiber board or mica and other forms useful for electrical insulation.

Dielectric strength of silicone resins is of the order of 1,500 to 2,000 volts per mil on thin sections. Silicone-bonded inorganic insulation does not crack or carbonize; dielectric constant of fourmil glass cloth coated with silicone tested at 25 deg. C. and 50 percent relative humidity is 3.5 at 1,000 cycles; power factor at 1,000 cycles is 0.7 percent.

Temperatures up to 345 deg. F. or higher do not appear to have any deteriorating effects.

Silicone fluids, like other basic types of silicones are unusually temperature stable. One such fluid with a viscosity close to that of water freezes at about —125 deg. F. and boils at 300 deg. F. The logarithmic curve of the viscosity of silicone fluids is a straight line, viscosity varying much less than the best grade of hydraulic oil. The possible use of silicone fluids as lubricants is being investigated. The flat or negative meniscus of silicone liquids makes for accurate reading of level in sight gages.

Only minute amounts of silicone liquid prevents the foaming of lubricating and other types of oil. Silicone fluids are also used to prevent plastic materials from sticking to the mold.

Silicone greases maintain their consistency throughout the temperature range from —40 deg. F. to 400 deg. F. These qualities have lead to its use as lubricant for stop cocks and pressure lubricated valves.

Gaskets of silicone rubber have been used on searchlights where they were subjected to temperatures as high as 570 deg. F. without deterioration. Silicone rubbers do not swell in oil, gasoline or other hydrocarbons. On the other hand, the material is deficient in tension, shear and abrasion. Silicone rubber is outstanding for applications where resilinecy and flexibility must be retained over a wide temperature range and resistance to moisture and oil are essential.

Release and Control of Advance Engineering Information

JAMES E. THOMPSON
Chief Engineer, Booth Manufacturing Corporation

A stop-work order is discussed; a method of providing temporary information so that manufacture can continue while drawings are being revised is presented; and a system for furnishing manufacturing data not ordinarily found on drawings is described. This is the sixth article in a series. Reference is made to a previous article in the July 1945 Number.

EVERY engineering department requires simple, practical means for rapidly issuing instructions to the manufacturing departments. To issue a new drawing or a drawing change usually consumes too much time when manufacture of a part must be stopped, information in advance of a drawing change is needed, and special engineering authorization for tests, drawing deviations and parts salvage are required.

A small engineering department will have less need for a system of advance drawing changes than a large department, wherein a week or more may be required to process the drawing through the release system. In all sizes of departments there is a genuine need for stop orders and engineering orders. A positive method of halting manufacture is necessary; a record of drawing deviations and salvaged parts must be kept.

Three forms are used to convey advance engineering information; namely, a Stop Order, Advance Drawing Change, and Engineering Order, as shown in Figs. 3, 4 and 5. Separate, distinctly different, forms are used for each. Possibility of confusion is thereby eliminated, and maintaining records of them is simplified. Each form is 8½ x 11 in. preferably a hectograph master to permit rapid duplication of copies. The same form upon tracing paper for blueprint duplication serves almost as well.

Stop Orders

A Stop Order is issued when manufacturing operations on a part must be halted immediately and when impending changes will require the reworking or scrapping of parts or the disassembly of units. Judgment must be used in the issuance of Stop Orders, for sometimes halting work on a large assembly is more expensive than the completion of some parts, even though the parts may be scrapped later.

Stop Orders originate in the engineering department initially as proposed Stop Orders, which serve as requests for parts-status surveys, and later as orders that actually stop work. Parts-status reports are obtained from the manufacturing planning department.

A typical Stop Order is shown in Fig. 3. In the proposal stage the following data are entered on the form: the production serial number of the unit upon which the stop will be effective; the model; part name; part number; dash-number parts affected (only those listed are stopped); and the reason for the stop. The effect of the stop upon the raw materials required for manufacturing the part is also shown.

The proposed Stop Order is delivered to the engineering Release group for forwarding to the manufacturing planning department. This does not constitute release of the stop, but is simply an official request to manufacturing planning to furnish a work-status report on the part.

Upon receipt of the proposed Stop Order manufacturing planning makes an investigation to obtain information on materials, tooling and parts affected by the proposed stop. These data are entered in the spaces on the stop order marked "raw stock," "tooling" and "parts status." The Stop Order is then returned to its originator in the engineering department.

After receiving the work-status report, the engineering supervisor who initiated the proposed stop decides upon the advisability of its issuance. It may be found that while a change is desirable, the quantity of completed parts makes the change not feasible. On the other hand large quantities of raw-stock materials may have been received, and the delay required to obtain new materials would be prohibitive. A considerable quantity of expensive tooling may have been completed, and the change would necessitate either scrapping or reworking of them.

In each case it is necessary to weigh the cost of the change against the improvement gained by the change. This assumes that the proposed change may be classified as desirable, rather than mandatory as the consequence of design deficiencies or changes in customer requirements. In the latter case there is no question about issuing the Stop Order as soon as possible. The work-status report is then useful only in determining the best methods of salvaging as much as possible of the completed tools and parts.

If the final decision is to issue the Stop Order, the approval of the project engineer is obtained, and the Stop Order is forwarded to engineering Release for duplication and distribution of the required copies. The original Stop Order is filed after duplication; copies are attached to each print.

Should the decision be against issue, the Stop Order is marked "void" and forwarded to Release. Copies are distributed only to the engineering department and to the manufacturing planning files; none is attached to prints. This procedure informs the manufacturing planning department of the disposition of every Stop Order that served as a request for a work-status report, and avoids uncertainty regarding pending stops. This is necessary in fairness to manufacturing planning, for each stop disrupts their schedule of production, and even the suggestion of a stop is cause for concern.

There may arise circumstances that make mandatory the issuance of an immediate stop on a certain part. This can be done without securing a work-status report from manufacturing planning, upon authorization by the chief engineer.

Stop Orders on parts for experimental models are not sent to manufacturing planning for a work-status report, as shown by the routing in Fig. 1. The quantity of parts and materials for an experimental model is small, and speed in issuing the stop is the paramount issue.

The issuance of a Stop Order not only halts all work in the factory on the part affected, but also prevents further release of its drawing. In other words, the stop must be released before the drawing can be released again under the next drawing change letter or revision.

Release of Stop Order

After the necessary drawing changes have been made, the Stop Order is released by entering the appropriate information at the

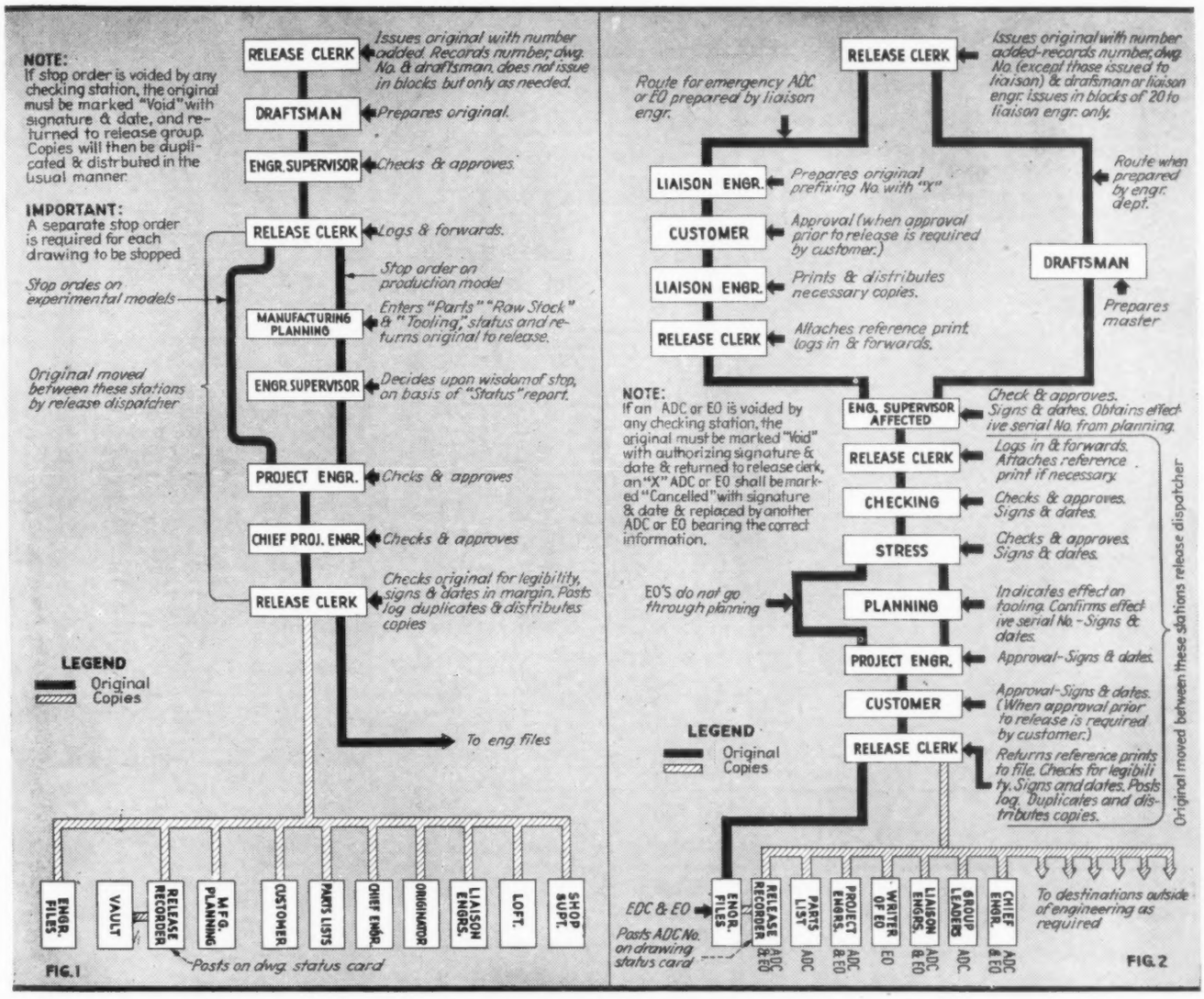

NOTE:
If stop order is voided by any checking station, the original must be marked "Void" with signature & date, and returned to release group. Copies will then be duplicated & distributed in the usual manner.
IMPORTANT:
A separate stop order is required for each drawing to be stopped.
Stop orders on experimental models
Original moved between these stations by release dispatcher
RELEASE CLERK
Issues original with number added. Records number, dwg. No. & draftsman, does not issue in blocks but only as needed.
DRAFTSMAN
Prepares original.
ENGR. SUPERVISOR
Checks & approves.
RELEASE CLERK
Logs & forwards.
Stop order on production model
MANUFACTURING PLANNING
Enters "Parts" "Raw Stock" & "Tooling," status and returns original to release.
ENGR. SUPERVISOR
Decides upon wisdom of stop, on basis of "Status" report.
PROJECT ENGR.
Chcks & approves
CHIEF PROJ. ENGR.
Checks & approves
RELEASE CLERK
Checks original for legibility, signs & dates in margin. Posts log, duplicates & distributes copies
To eng files
LEGEND
Original
Copies
ENGR. FILES
VAULT
RELEASE RECORDER
M.F.G. PLANNING
CUSTOMER
PARTS LISTS
CHIEF ENGR.
ORIGINATOR
LIAISON ENGRS.
LOFT.
SHOP SUPT.
Posts on dwg. status card
FIG. 1
RELEASE CLERK
Issues original with number added-records number, dwg. No. (except those issued to liaison) & draftsman or liaison engr. issues in blocks of 20 to liaison engr. only.
Route for emergency ADC or EO prepared by liaison engr.
Route when prepared by engr. dept.
LIAISON ENGR.
Prepares original prefixing No. with "X"
CUSTOMER
Approval (when approval prior to release is required by customer.)
LIAISON ENGR.
Prints & distributes necessary copies.
DRAFTSMAN
Prepares master
RELEASE CLERK
Attaches reference print, logs in & forwards.
NOTE:
If an ADC or EO is voided by any checking station, the original must be marked "Void" with authorizing signature & date & returned to release clerk, an "X" ADC or EO shall be marked "Cancelled" with signature & date & replaced by another ADC or EO bearing the correct information.
ENG. SUPERVISOR AFFECTED
Check & approves. Signs & dates. Obtains effective serial No. from planning.
RELEASE CLERK
Logs in & forwards. Attaches reference print if necessary.
CHECKING
Checks & approves. Signs & dates.
STRESS
Checks & approves. Signs & dates.
EO'S do not go through planning
PLANNING
Indicates effect on tooling. Confirms effective serial No. - Signs & dates.
PROJECT ENGR.
Approval - Signs & dates.
CUSTOMER
Approval - Signs & dates. (When approval prior to release is required by customer.)
RELEASE CLERK
Returns reference prints to file. Checks for legibility. Signs and dates. Posts log. Duplicates and distributes copies.
Original moved between these stations release dispatcher
LEGEND
Original
Copies
EDC & EO
Posts ADC No. on drawing status card
ENGR. FILES
RELEASE RECORDER
PARTS LIST
PROJECT ENGRS.
WRITER OF EO
LIAISON ENGRS.
GROUP LEADERS
CHIEF ENGR.
ADC & EO
ADC
EO
To destinations outside of engineering as required
FIG. 2

Fig. 1—Flow chart showing procedure for issuance of a Stop Order. Fig. 2—Flow chart showing the procedure in approving, checking and releasing Advance Drawing Changes and Engineering Orders.

bottom of the stop original, and substituting the word "RELEASE" for the word "ORDER" at the top of the form, Fig. 3. The original used to issue the stop is employed to effect its release. Thus both the stop and its release bear the same serial number to insure immediate coordination. The Stop Release accompanies the new or changed drawing through the engineering checking and approval system. In no case is the Stop Release forwarded separately.

The Stop Release always indicates the disposition of finished parts in stores. All drawing change notices associated with the stop must show identical stock disposition instructions, and bear the notation, "This releases Stop Order (number)."

Sometimes it will be found that a stop has been issued in error, or subsequent investigation may reveal facts which make the stop unnecessary. In such cases the Stop Order is cancelled. This is accomplished by placing the notation "use without change" in the stop release block entitled "special," and forwarding the stop original to the Release group for distribution of the copies.

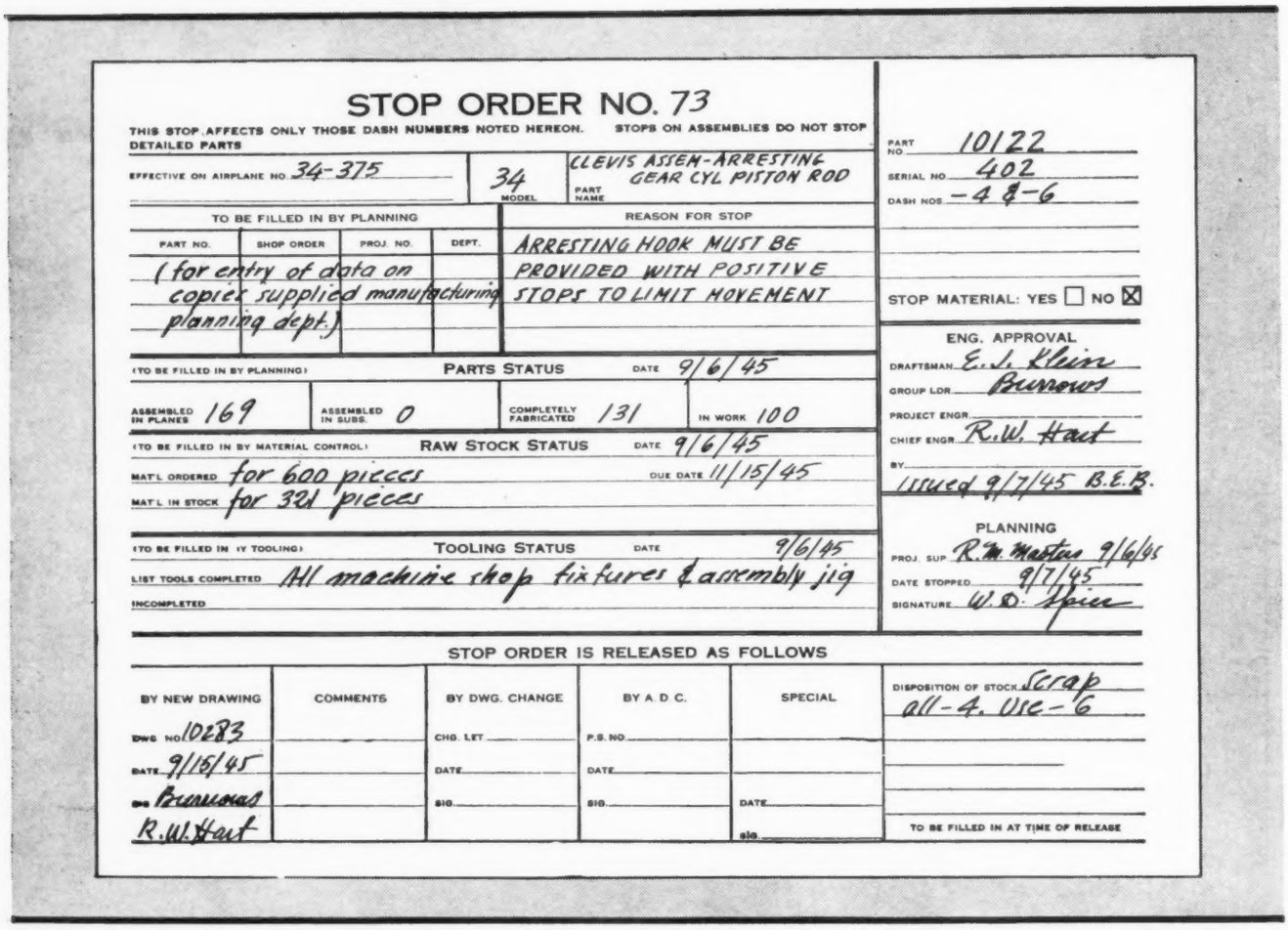
A record of each Stop Order and Stop Release is maintained by engineering Release, using the drawing status record cards for that purpose (see PRODUCT ENGINEERING for July 1945 pages 465-470). The Stop Order number, date and effective production serial number are recorded at the time copies of the stop are distributed. Upon release of the stop, the date of its distribution is posted on the record. A red signal is placed upon the status card for the stopped drawing when the stop is distributed. It remains there until the stop is released.

Stop Orders should be released as soon as possible, as each causes a production delay. The stopping of one part usually results in hindering the completion of others. A part upon which work has been stopped prevents completion of its subassembly, and lack of that subassembly may prevent completion of the final product. A weekly summary of Stop Orders and Stop Releases is prepared and distributed to all engineering supervisors and executives by engineering Release. The report lists all active stops, and those released during the preceding week; and serves as a reminder to take action on unreleased stops.

Advance Drawing Changes

The form shown in Fig. 4, Advance Drawing Change or ADC, is used by the engineering department when the need to authorize a drawing change is so urgent that it cannot be handled with sufficient rapidity through the regular release procedure. The issuance of an ADC is a guarantee that the drawing will be changed accordingly and released again as soon as practicable. An ADC may be issued in lieu of a drawing when time does not permit preparing and releasing a new drawing in the usual manner. In such cases a new drawing number is assigned for the new part described.

The ADC is used only for information to be incorporated in a drawing. The issuance of special information not relating to draw-



STOP ORDER NO. 73

THIS STOP AFFECTS ONLY THOSE DASH NUMBERS NOTED HEREON. STOPS ON ASSEMBLIES DO NOT STOP DETAILED PARTS

EFFECTIVE ON AIRPLANE NO. 34-375 | 34 MODEL | CLEVIS ASSEM-ARRESTING GEAR CYL PISTON ROD PART NAME

PART NO. 10122 | SERIAL NO. 402 | DASH NOS. -4 & -6

TO BE FILLED IN BY PLANNING

PART NO.	SHOP ORDER	PROJ. NO.	DEPT.
(for entry of data on copies supplied manufacturing planning dept.)			

REASON FOR STOP: ARRESTING HOOK MUST BE PROVIDED WITH POSITIVE STOPS TO LIMIT MOVEMENT

STOP MATERIAL: YES ☐ NO ☒

ENG. APPROVAL
DRAFTSMAN E. J. Klein
GROUP LDR. Burrows
PROJECT ENGR.
CHIEF ENGR. R. W. Hart
BY
Issued 9/7/45 B.E.B.

(TO BE FILLED IN BY PLANNING) PARTS STATUS DATE 9/6/45

ASSEMBLED IN PLANES	ASSEMBLED IN SUBS.	COMPLETELY FABRICATED	IN WORK
169	0	131	100

(TO BE FILLED IN BY MATERIAL CONTROL) RAW STOCK STATUS DATE 9/6/45

MAT'L ORDERED for 600 pieces DUE DATE 11/15/45
MAT'L IN STOCK for 321 pieces

PLANNING
PROJ. SUP. R. W. Hart 9/6/45
DATE STOPPED 9/7/45
SIGNATURE W. D. Spier

(TO BE FILLED IN BY TOOLING) TOOLING STATUS DATE 9/6/45

LIST TOOLS COMPLETED All machine shop fixtures & assembly jig
INCOMPLETED

STOP ORDER IS RELEASED AS FOLLOWS

BY NEW DRAWING	COMMENTS	BY DWG. CHANGE	BY A. D. C.	SPECIAL
DWG NO. 10283		CHG. LET.	P.S. NO.	
DATE 9/15/45		DATE	DATE	
Burrows		SIG.	SIG.	DATE
R. W. Hart				SIG.

DISPOSITION OF STOCK Scrap all-4. Use-6

TO BE FILLED IN AT TIME OF RELEASE

Fig. 3—A typical stop order. An 8½x11 in. hectograph form permits rapid duplication. When the Stop Order is released the spaces at the bottom of the form are filled in and the word "Release" is substituted for "Order".

ing changes is accomplished by the Engineering Order shown at Fig. 5. The two forms keep information relating only to drawing changes segregated from that which is not shown on drawings.

A copy of each ADC is attached to every print of the drawing affected. Their use permits immediate issuance of change information without the necessity of reprinting the drawing and of issuing revised prints to all departments.

Each ADC is prepared by, or under the direction of, an engineering supervisor. It lists the reason for the change, the drawing number, the part name, and other information. See Fig. 4. Sketches and explanations clearly indicate the action to be taken by the manufacturing departments.

After an ADC is prepared it is forwarded to the Release section for routing through the system. The ADC is routed in a manner shown at Fig. 2 for a large aircraft company. The release system includes checking and approval by the checking group, stress group, manufacturing planning department, project office and customer's representative. A small engineering department, or one engaged in the design of comparatively simple products, will not usually require the complete system shown in Fig. 2. In such cases the system can usually be confined to checking, followed by the chief engineer's approval. Accuracy of the change information given on the ADC is the liability of the engineering supervisor responsible for its issuance.

Since the only justification for the usage of an ADC is to decrease the time required to issue information to the manufacturing departments, the routing of ADCs through the checking and approval system cannot be left to chance. It is made the prime duty of an alert, aggressive member of the Release group. This employee personally forwards ADCs between release system stations and maintains a record of the time at each station in the system. A total time within the system of four hours is the maximum that can be allowed for an ADC, and it is the duty of the ADC expediter to prevent their release from being delayed beyond this period. When an ADC is delayed by circumstances beyond the authority of the expediter, he immediately refers the case to the chief draftsman or chief clerk, depending upon who is at fault.

Copies of the ADC are duplicated and distributed by the Release group. In addition to copies for various files throughout the company, one copy is attached to each regular-issue print of the drawing. A small hole is punched in the margin of the print, directly below the title block, each time an ADC is attached. This provides a ready check upon the completeness of the ADCs attached to the print. There should be the same number of ADCs attached as there are holes punched in the print margin. If not, the user of the print should obtain from Release the serial numbers of all active ADCs issued against that drawing. The missing attachments can then be identified, and copies obtained from Release.

When the ADC form does not provide sufficient space adequately to describe the change, it is necessary to make a supplementary sketch on tracing paper to accompany the ADC. In such cases the ADC is prepared in the usual manner, except that it is plainly marked "Sheet 1 of 2 sheets." The supplementary sketch is not assigned a drawing number, but instead is identified in the lower right-hand corner with the corresponding ADC serial number. It is marked "Sheet 2 of 2 sheets." All signatures appearing on the ADC also appear on the sketch. The ADC title block is placed on the sketch by the use of a rubber stamp.

The ADC and sketch are routed together. After the blueprint unit has prepared the

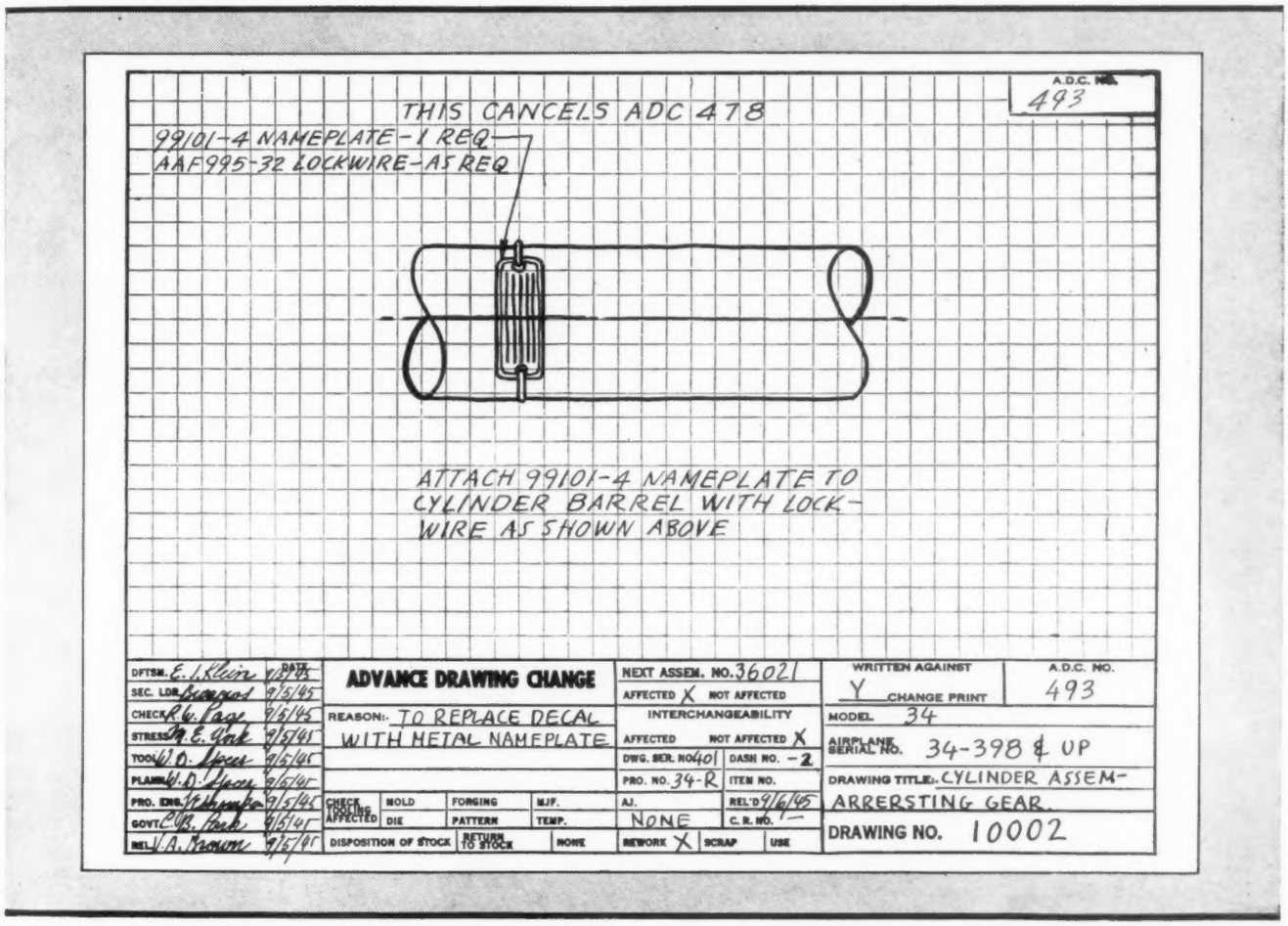

THIS CANCELS ADC 478
99101-4 NAMEPLATE - 1 REQ
AAF995-32 LOCKWIRE - AS REQ
A.D.C. NO. 493
ATTACH 99101-4 NAMEPLATE TO CYLINDER BARREL WITH LOCK-WIRE AS SHOWN ABOVE
ADVANCE DRAWING CHANGE
REASON: TO REPLACE DECAL WITH METAL NAMEPLATE
NEXT ASSEM. NO. 36021
AFFECTED X NOT AFFECTED
INTERCHANGEABILITY
AFFECTED NOT AFFECTED X
DWG. SER. NO. 401 DASH NO. - 2
PRO. NO. 34-R ITEM NO.
NONE
REL'D 9/6/45
C. R. NO. —
WRITTEN AGAINST Y CHANGE PRINT
A.D.C. NO. 493
MODEL 34
AIRPLANE SERIAL NO. 34-398 & UP
DRAWING TITLE: CYLINDER ASSEM-ARRESTING GEAR
DRAWING NO. 10002

Fig. 4—An Advance Drawing change provides urgent information so that manufacturing can proceed while drawings are being revised. The issuance of an ADC is a guarantee that the drawing will be changed to correspond.

required prints, the supplementary sketch is forwarded to engineering files for filing with the ADC original.

In every manufacturing enterprise of any size there is usually an engineering liaison function. The person or persons assigned to this duty serve as direct contact between the engineering and the manufacturing departments, receiving and answering all requests for engineering information and assistance. This insures that all requests from the manufacturing departments will be quickly and accurately answered, as well as provides complete coordination between the engineering and the other departments. In the absence of an engineering liaison function an unreasonable portion of an engineering supervisor's time is spent handling requests from the factory. Even worse, misinformation may be supplied the manufacturing departments—as the inevitable result of decentralized responsibility.

The liaison engineers are experienced, competent engineering personnel. They are authorized to issue emergency ADCs, without the necessity of formal checking and approval after normal working hours of the engineering department, or when the need for engineering authorization is so urgent that it cannot be handled through the regular release procedure.

Each emergency ADC has its serial number prefixed by "X" for identification. In some cases it may be necessary for the liaison engineer to obtain approval of the customer's representative prior to releasing the ADC. Only sufficient copies are distributed to take care of the immediate need. The ADC original is forwarded to the Release Section for processing and checking in the regular manner. After an emergency ADC has been approved in the regular manner, the "X" is removed from its serial number and copies are distributed in the usual manner.

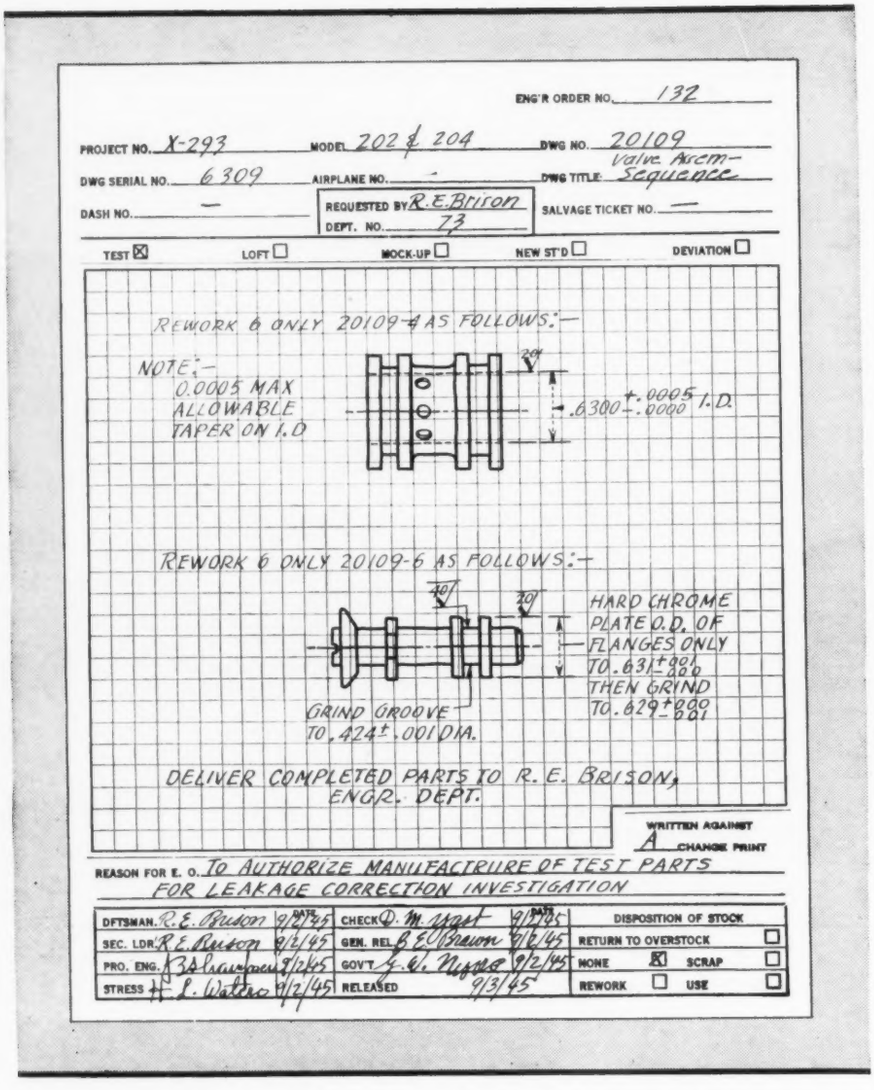
If the emergency ADC is found undesirable, or in error when checked, it is plainly marked "cancelled." Another ADC, cross-referenced to the cancelled emergency ADC, is issued to provide the correct information. When competent personnel are assigned to liaison engineering, the quantity of incorrect emergency ADCs will be small.

All ADCs show, in the space marked "written against—change print," Fig. 4, the change letter appearing on the drawing at the time the ADC is written. Thus, the letter "D" appearing in the change-letter space indicates that the ADC affects the "D" revision of the drawing, and should be incorporated in the "E" drawing change. A copy of the ADC should be attached to each regular-issue "D" revision print. ADCs written against drawings that do not bear a change letter show a dash in the change-letter space.

Changes cannot be made on an ADC after its release. Should it be found incorrect, another ADC is issued with the note: "This cancels ADC (number)." Should it be necessary to provide additional information, another ADC is issued, bearing the note "This supplements ADC (number)."

A change affecting several drawings requires a separate ADC for each drawing. In no case does one ADC relate to more than a single drawing. Several dash numbers on one drawing, however, can be covered by a single ADC. This procedure insures an orderly release of ADCs and a record of the distribution of them.

The production serial number upon which an ADC takes effect is obtained from the manufacturing planning department, except in the case of mandatory changes which must take effect upon a certain unit regardless of the disruption of production schedules. The desired effective serial number is shown on the ADC when it is forwarded to manufacturing planning for confirmation. If the requested serial number cannot be


ENG'R ORDER NO. 132

PROJECT NO. X-293 MODEL 202 & 204 DWG NO. 20109

DWG SERIAL NO. 6309 AIRPLANE NO. - DWG TITLE: Valve Assem-Sequence

DASH NO. — REQUESTED BY R.E. Brison DEPT. NO. 73 SALVAGE TICKET NO. —

TEST ☒ LOFT ☐ MOCK-UP ☐ NEW ST'D ☐ DEVIATION ☐

REWORK 6 ONLY 20109-4 AS FOLLOWS:—

NOTE:— 0.0005 MAX ALLOWABLE TAPER ON I.D.

.6300 +.0005 -.0000 I.D.

REWORK 6 ONLY 20109-6 AS FOLLOWS:—

HARD CHROME PLATE O.D. OF FLANGES ONLY TO .631 +.001 -.000 THEN GRIND TO .629 +.000 -.001

GRIND GROOVE TO .424 ± .001 DIA.

DELIVER COMPLETED PARTS TO R. E. BRISON, ENGR. DEPT.

WRITTEN AGAINST A CHANGE PRINT

REASON FOR E. O. TO AUTHORIZE MANUFACTURE OF TEST PARTS FOR LEAKAGE CORRECTION INVESTIGATION

DFTSMAN. R.E. Brison	9/2/45	CHECK D. M. Wyatt	9/2/45	DISPOSITION OF STOCK	
SEC. LDR. R.E. Brison	9/2/45	GEN. REL. R.E. Brison	9/2/45	RETURN TO OVERSTOCK	☐
PRO. ENG. K.B. Lawrence	9/2/45	GOV'T G.C. Myers	9/2/45	NONE ☒ SCRAP	☐
STRESS H. L. Walters	9/2/45	RELEASED	9/3/45	REWORK ☐ USE	☐

Fig. 5—An Engineering Order is used, as an aid in manufacturing and assembly, to supply special information that does not appear on drawings.

met without disrupting production schedules, it will be changed by manufacturing planning to one that can. Selection by the engineering department of a reasonable effective serial number is simplified when manufacturing planning uses a block-release system for issuance of shop orders. Thus, all changes within a given calendar period accumulate against the starting serial number of the next production release.

In general it is not economical to issue ADCs against small drawings, such as the "A" and "B" sizes, i.e. 8½x11 and 11x17 in., respectively. Instead, the change should be made directly upon the drawing affected. Exceptions to this rule are emergency ADCs listed by liaison engineers.

Whenever an ADC is incorporated in its drawing, the ADC original is marked "Incorporated," with date, change letter and the signature of the person obsoleting the ADC. The obsolete original is then returned to engineering files.

The drawing change notice accompanying a changed drawing lists the serial numbers of all ADCs incorporated by the change in the "authority for change" column. This authorizes Release to list the ADCs as incorporated on the status-record cards for the drawing affected. The drawing-status record cards provide for listing all ADCs issued against each drawing, as well as a column for indicating the change letter. This information is entered by engineering Release; first, when the ADC original passes through Release, and later when the changed prints incorporating the ADC are released.

The prime reason for an ADC is speed in conveying information to the manufacturing departments, and in most cases freehand sketching is entirely adequate. Accurate information is the important consideration, which can be conveyed quickly and conveniently by well-drawn sketches.

It may be found desirable to route all ADCs affecting production models to the tool design department, prior to release. This will prevent release of ADCs that adversely affect tooling, and avail the engineering department of information on alternate methods of accomplishing the change at less expense. When this practice is followed, the tool-design department checks all production ADCs for effect upon tooling and approves those found satisfactory. Objectionable ADCs are referred to the project engineer, who arranges a compromise satisfactory to both engineering and the tool design department.

Engineering Orders

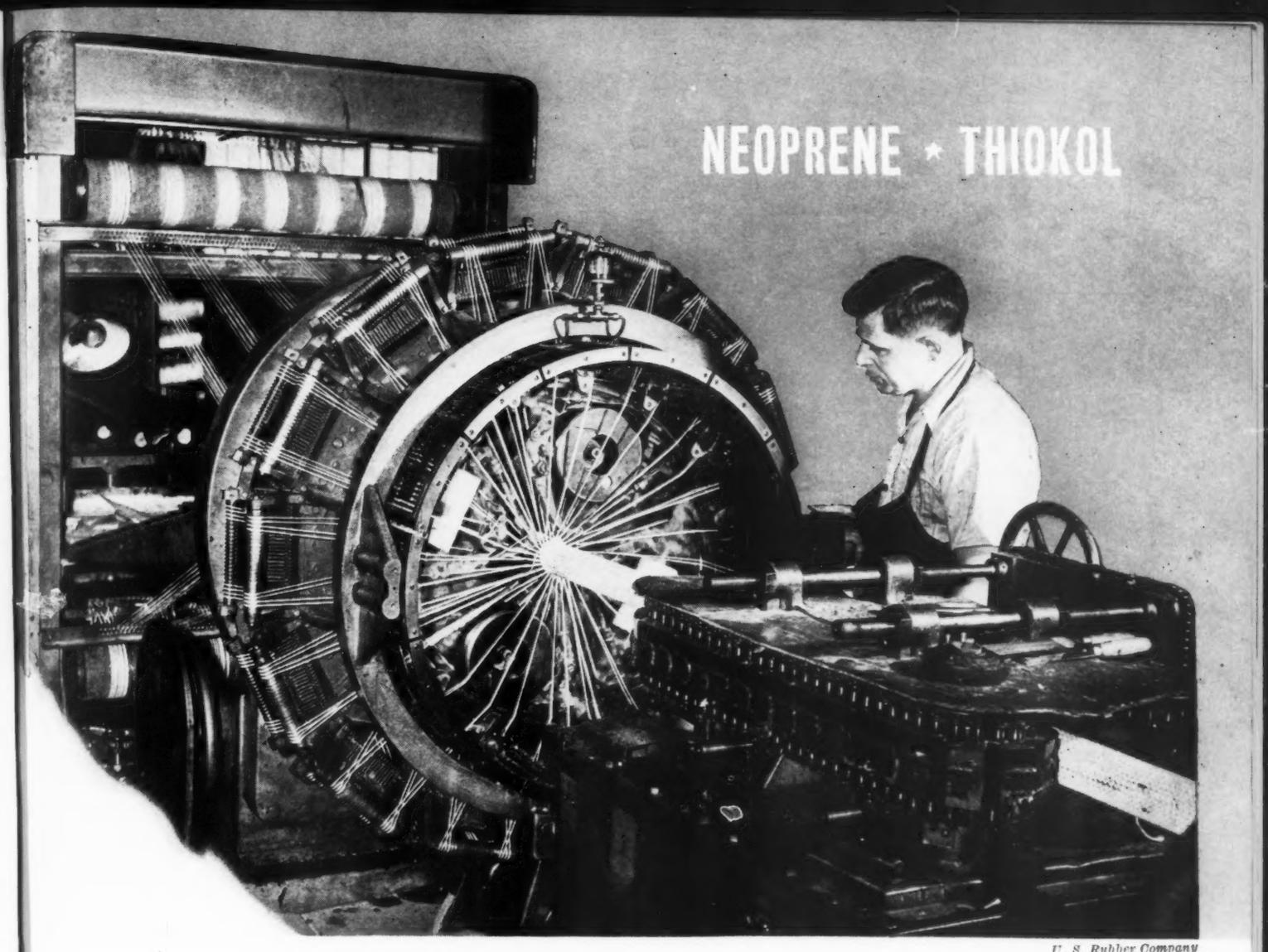
The Engineering Order, EO form, Fig. 5, is used by the engineering department to effect the rapid release of information not incorporated on a drawing, such as drawing deviations, parts salvage, test instructions and authorization for the manufacture of mock-up parts. Engineering orders are not issued to cover design material or dimensional changes. An EO should affect as few units as possible, and never be issued to cover large portions of a contract. An ADC should be issued when a quantity of units are involved.

A deviation EO is frequently issued to authorize the re-work of parts in cases where the actual drawing change will show a different alteration of the parts. Parts that deviate from their drawing in a manner that cannot be re-worked to the drawing dimensions are often usable. In such cases the parts are not scrapped, and an EO deviation authorizes their acceptance by the inspection department as salvage.

The basic procedure for releasing EOs is similar to that used for ADCs, as shown in Fig. 2. The only variation is elimination of manufacturing planning as a station in the release system. Engineering Orders do not affect tooling. The effective serial number is usually based upon actual need for a drawing deviation.

When an EO is issued to authorize fabrication of a new test part or to aid an installation, a drawing number is assigned to identify the part or installation. The serial number of the EO is shown in the drawing number assignment record. If the test part is found to be satisfactory for production, a drawing or an ADC is issued to release the part for manufacture. If unsatisfactory, the drawing number is cancelled. When the EO describes an assembly, dash numbers are used to identify the detail parts thereof, unless they are already described by detail drawings. Dash numbers used for EO part identification are not dash-numbers of a drawing.

The general rules governing use of advance drawing-changes also apply to EOs. The principal difference in procedure for the two forms is the fact that EOs are never incorated in the drawing. They are listed on the drawing status record cards for reference purposes only. One copy of the EO is attached to each regular-issue print bearing the same change letter.



U. S. Rubber Company

SYNTHETIC RUBBER IN ENGINEERING DESIGN—II

Characteristics, properties, applications and limitations of Neoprene and Thiokol synthetics. Butyl, acrylonitrile and *GR-S* rubbers were discussed in a report published in November 1945. In these editorial reports, no attempt is made at over-all comparison; rather each material is thoroughly analyzed by a competent authority in that particular field.

In a previous issue (November 1945) the report on synthetic rubber included four articles: Specification, Butyl, acrylonitrile and GR-S. A brief resumé of the article content is offered below as an aid to the engineer desiring information on synthetic rubbers and their application.

* * *

Any discussion of synthetic rubbers must necessarily be preceded with an analysis of the peculiar characteristics of resilient materials and the effect of these characteristics on test methods and specifications. In the article, "Factors Affecting Selection of Synthetic Rubber" it is stated that, "Materials with elastic qualities are fundamentally much more complex than most other substances used in engineering construction. Contrasted with the relatively simple crystalline character of steel, for example, resilient compounds have intricate semiplastic, colloidal structures which are capable of almost infinite variation because of the hundreds of available ingredients from which they may be compounded.

"Because of this complexity, the properties of resilient materials are difficult to define. Terms used in defining the properties of resilient products in many cases have different meanings than the same terms applied in other fields of engineering. The term "resilience," for example conveys a different meaning when applied to metals or alloys than when used in connection with elastic materials. Successful utilization of elastic products in design work, therefore, requires a careful consideration of the definitions of their properties from the point of view of

the rubber technologist selecting the material."

The article points out that knowledge of test methods is absolutely essential and that it is difficult to interpret test results in terms of probable service life because, "The problem of predicting probable service life would be simplified if all of the available experience data could be applied to compositions recognized by the rubber industry as standards. But there are no accepted basic compositions such as have been compiled for metals and alloys. A system of standard compounds is not practical because differences in manufacturing procedures for different products make variations in composition a necessity; differences in equipment design require different formulations and will result in variations in the final product despite identical compositions. Rapid advances in technology in the industry and the relative ease of making changes in composition on an industrial scale dictate a fluid structure."

The article also discusses the four basic methods of specifying a synthetic:

1. Specify a definite synthetic rubber compound with which the engineer is familiar and which has performed successfully in the application under consideration or similar application.

2. Specify a synthetic rubber compound which complies with some standard specification of a recognized association such as the American Society for Testing Materials or the Society of Automotive Engineers.

3. Write a detailed specification designed to produce a compound having the necessary physical and chemical properties.

4. State the service conditions fully and accurately and rely on the technical staff of the rubber products manufacturer to furnish a material or part that is adequate.

The fourth method of procedure is recommended as most successful for new applications.

Butyl Rubber by L. B. Turner, Esso Laboratories, Standard Oil Development Company and E. N. Cunningham, Stanco Distributors, Inc.

This report covers basic formulations and then gives specific data on physical properties, including tensile, abrasion resistance, compression set and emphasizes particularly the effects of temperature on these properties. Aging, diffusion resistance and chemical resistance are also discussed, as are electrical properties. See Product Engineering, Nov. 1945, pages 764-769.

* * *

Butadiene-Acrylonitrile Rubbers by J. A. Tallant, Manager, Technical Data Service, Hycar Chemical Company.

Processing, stress-strain characteristics, resilience, flex life, abrasion resistance, temperature effects, oil resistance, and bonding are included in this article which also gives specific data on design factors and applications. See Product Engineering, Nov. 1945, pages 770-774.

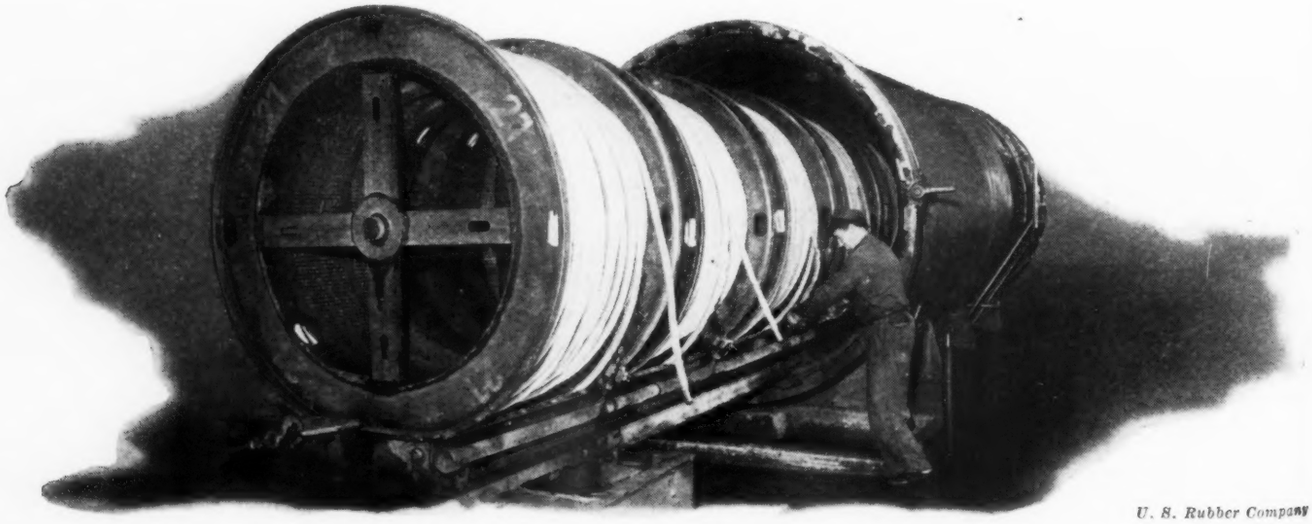
* * *

GR-S Synthetic Elastomers by A. E. Juve, Research Department, B. F. Goodrich Company.

GR-S is compared as to processing characteristics and properties with natural rubber. Specific data is given on those properties in which *GR-S* is superior to natural rubber and those in which *GR-S* compounds are inferior, along with a discussion of these properties and product design. See Product Engineering, Nov. 1945, pages 775-776.

* * *

In the following pages, similar data on Neoprene and Thiokol synthetics is presented. Thus the engineer has, in these two special reports, a comprehensive file of specific information on new synthetics and their suitability to new product applications. In future issues, new rubber-like synthetics will be discussed as engineering data and application data becomes available.



U. S. Rubber Company

Fig. 1—Typical moldings of Neoprene synthetic rubbers

Neoprene in Product Design

V. A. COSLER

Sales Development Manager, Rubber Chemicals Division
E. I. duPont de Nemours & Company

THE BASIC PROPERTIES of Neoprene compositions correspond rather closely with those of like compositions of natural rubber. It is practically impossible to make a more detailed statement than the above. There are thousands of different Neoprene compositions all of which vary slightly with respect to physical properties; and the same is true of rubber compositions. Therefore, a comparison of the specific characteristics of rubber and neoprene compounds must either be made in broad general terms or be accompanied by voluminous data. A brief discussion of the basic properties of Neoprene compositions follows.

Neoprene compounds can be supplied in essentially all degrees of hardness obtainable with resilient materials. In terms of Shore A Durometer data, this includes hardnesses ranging from 20 to 90. Compounds having a hardness of less than 30 or greater than 80 are generally of rather limited utility since these extremes are obtained only at the sacrifice of some of the more desirable characteristics of compounded elastomers. Neoprene compounds cannot be vulcanized to the hardness of ebonite or hard rubber.

Specific Gravity

Crude Neoprene has a specific gravity of 1.25 whereas rubber has a specific gravity of 0.93. Most Neoprene compounds have specific gravities that fall within the range of 1.30 to 1.80 whereas the range of rubber compositions is from 1.15 to 1.70 but, in general, this relatively high specific gravity does not limit the utility of the compounds since there are few uses in which the weight of a product is of great importance.

Tensile Strength

The tensile strength can be varied from 200 lb. per sq. in. to 4,500 lb. per sq. in., depending upon the type and quanity of the various compounding ingredients used. Although it is often helpful to have some knowledge concerning the tensile strength of a given compound, the number of cases where tensile strength can be correlated with actual service performance is so small that the quality of the product usually cannot be adequately defined in terms of this property alone. For instance, Neoprene compounds possessing the greatest abrasion resistance are not necessarily those of highest tensile strength. With natural rubber the converse is generally true.

Abrasion Resistance

In general, Neoprene compounds exhibit essentially the same resistance to abrasion as do those of rubber but, as indicated in the foregoing discussion, this does not signify that all of the other characteristics of such compounds will be identical or even similar to those of the corresponding rubber com-

Fig. 2—Neoprene compositions are often extruded in a variety of cross-sections.

pounds. On the other hand, it should not be inferred from this that abrasion resistance is secured at the sacrifice of certain essential properties because, by proper compounding, considerable control can be exercised over the secondary characteristics of abrasion resistant Neoprene compounds. From a practical standpoint, the retention of abrasion resistance after exposure to heat, oil and other deteriorating influences is at least as important a characteristic as initial abrasion resistance. Neoprene compounds display slightly better resistance to cutting than rubber compounds and somewhat poorer tear strength.

Comparative Properties

Resilience is slightly lower than like compositions of rubber and permanent set is slightly higher. However, these differences are so small as to have little significance in connection with their use in vibration dampening equipment, and in certain applications Neoprene compositions have characteristics not obtainable with rubber.

Many gases which diffuse through natural rubber films quite rapidly can be retained by Neoprene. This statement should be interpreted as meaning that the permeation rate of these gases for Neoprene is very much lower than for comparable rubber compounds and not that Neoprene is absolutely impermeable. Tests on freshly-prepared films show that the compounds possess inherently superior gas-retaining characteristics and, in addition, their utility in gas retaining products such as balloons and flotation gear is enhanced to a considerable extent by the ability to retain this property upon exposure to deterioration by such influences as sunlight, abrasion and oxidation.

Thermal conductivity is somewhat higher then that of rubber compositions of a similar type. For instance, a "pure gum" Neoprene compound displays a coefficient of thermal conductivity of 1.45 B.t.u. per hr. per sq. ft. per in. thickness for a temperature differential of 1 deg. F. while a corresponding rubber compound shows a conductivity of 1.13 B.t.u. Since these values are of the same general order of magnitude, Neoprene should be regarded as a heat insulating material but, in applications such as vibration dampening, this difference may often play an important part in dissipating heat generated by rapid distortion.

Electrical Properties

Electrical insulating properties are quite inferior to those of rubber since volume resistivities ranges from 3.1×10^{2} to 1.5×10^{2} ohms per cm. at 25 deg. C., depending upon the composition. Therefore, Neoprene compounds are not employed in insulators for high-voltage or high-frequency service. However, superior resistance to degradation by ozone, heat, oil, abrasion makes Neoprene suitable for use in cable covers to protect the insulation material.

The superiority of Neoprene compositions over those of rubber is best displayed in connection with tests for stability. In many cases the basic characteristics of Neoprene are only equal to those of rubber, but under most service conditions these characteristics are retained over a greater length of time in the case of natural rubber compounds. Some of the characteristics in which Neoprene compounds are superior to those of natural rubber are discussed in the following paragraphs:

Resistance to Gasoline and Oils. The degree of resistance differs with the type of oil, but Neoprene is more resistant than rubber to petroleum products, vegetable oils, animal fats and fish oils. Neoprene compounds swell in oils to a lesser extent than rubber products. More important, tensile strength is much less affected. For example, a Neoprene composition, after 72 hours immersion in lubricating oil (S. A. E. No. 30) at 30 deg. C., shows a volume increase of only 3.7 percent, as compared to 38.4 percent for a like compound of natural rubber, and exhibits a tensile-strength loss under these conditions of only 27.4 per cent as compared to 75 per cent for the rubber product. Likewise a rubber compound immersed in hot lard swelled badly and disintegrated in thirty days; a Neoprene compound swelled but was otherwise in good condition.

Resistance to Chemicals. Neoprene products resist deterioration by most chemi-

cals, although in many cases a special Neoprene composition should be used for a given type of chemical. Sulfuric acid and hydrochloric acid, in concentrations of 30 percent, cause little deterioration, and higher concentrations of hydrochloric acid have been handled by special compositions. Chlorine, bromine and iodine have some effect but the Neoprenes are superior to rubber compositions, which are rapidly oxidized. Chlorinated hydrocarbons such as carbon tetrachloride produce pronounced swelling and deterioration of both Neoprene and rubber. Neoprene is much more resistant than rubber to "Freon" fluorine refrigerants, methyl chloride and sulfur dioxide, in both the gas and liquid phase.

Resistance to Sunlight. One of the worse enemies of natural rubber is direct sunlight, which produces a deteriorating effect described as "sun checking." Neoprene products are practically unaffected by sunlight, the only change being a slight stiffening upon prolonged exposure. In one test a Neoprene compound exposed to sunlight for 26 months was still in good condition, while a rubber compound was badly cracked after only thirteen months.

Resistance to Heat. All Neoprene compounds are markedly superior to natural rubber in this respect, but best results are obtained by use of special types. These show greatest superiority over rubber at temperatures between 180 deg. and 300 deg. F. Vulcanized compositions do not undergo reversion (softening and weakening) at high temperatures, as rubber compounds do.

Flame Resistance. Unless the compounds contain a high proportion of oils or organic diluents they do not support combustion and do not propagate flame. This has been of particular importance in such applications as jackets for ship cables, where rubber jackets in the past sometimes carried fire from one part of the ship to another. Neoprene sponge rubber products display a marked superiority in flame retardation.

Aging and Ozone Resistance. Natural rubber deteriorates with age, even in the absence of sunlight, heat or chemicals. This deterioration is due to atmospheric oxidation, and while the anti-oxidants used in rubber compounds in recent years have greatly retarded this destructive action it is still a problem to the manufacturer and user of rubber goods. Neoprene, however, is more resistant to oxidation than the best modern rubber compounds. This superiority has been demonstrated by natural aging tests conducted over a period of years and by an accelerated test in which the compounds are exposed to oxygen under a pressure of 300 lb. per sq. in. at 158 deg. F. A high-grade natural rubber compound when subjected to the "oxygen bomb" conditions for forty days cracked on the surface and became mushy inside. A typical Neoprene compound stiffened slightly but retained most of its original strength and toughness even after 100 days in the oxygen bomb. Neoprene compositions also possess a high resistance to ozone, a property that makes them of particular value as a jacketing composition for insulated wire in high-voltage or high-frequency service, since ozone generated by the corona discharge around such conductors is particularly destructive to rubber insulation and to other types of jacketing materials.

Applications

The bulk of Neoprene war production went into articles for direct military use. These include gas masks, life belts, life rafts and pontoons, "exposure suits" to protect aviators forced down over water, protective jacketing for ship cables, airplane wiring and Army field telephone lines, decontamination gloves, barrage balloons, antenna balloons for life raft radio sets, carburetor diaphrams for airplane motors, delousing bags, helmet liners, hose and tubing for use of the Army, Navy and Air Corps, and thousands of molded articles for planes, tanks and mobile equipment.

A small proportion of the output has been assigned to tasks on the industrial front: tanker hose, oil seals, transmission and conveyor belts, acid-resistant coveralls, gloves, hoods, aprons and boots, and numerous essential machinery parts.

In the domestic and home equipment fields, as well as in many of these industrial applications, Neoprene gave a good account

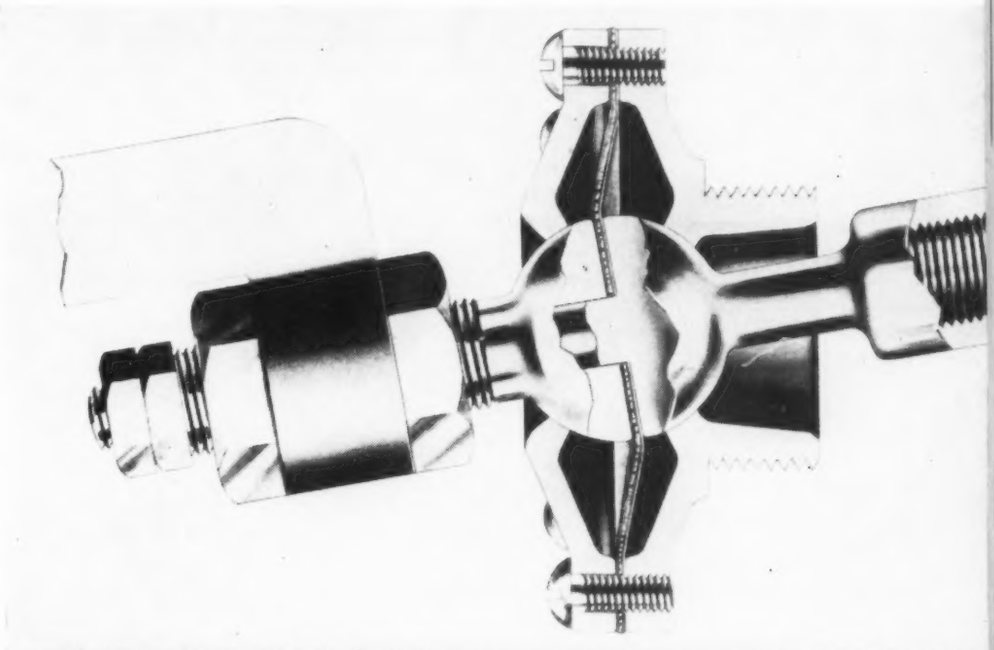


Fig. 3—Effective sealing against oil and other liquids is provided in this ball and socket joint by a Neoprene diaphragm.
Fig. 4—Flexible hose molded of Neoprene, used in gas mask.

of itself before the war. Its resistance to fats and oils made it particularly adaptable to such things as sink mats and strainers, dish racks, scrapers and household gloves. Faucet washers of Neoprene wore longer than rubber because they were less affected by hot water. Neoprene compounds went into soles for sports and work shoes. Neoprene-coated fabrics were used for heavy work gloves.

Many additional products in this general field are expected in the post-war period. Experimental quantities have been made available from time to time in the past, however, for development of new products. Among the applications that have been tried experimentally and found promising are weather stripping, and refrigerator door seals. Foam sponge, made from Neoprene latex, is expected to find wide use. It will resist sterilizing steam or sunlight better than rubber sponge.

In the field of machinery and industrial equipment the service value of Neoprene has been proven by use in a greater variety of products and applications than by any other synthetic rubber. Technicians in rubber manufacturing plants have done and are doing much research and development work to produce the hundreds of combinations of Neoprene and compounding ingredients appropriate for various service conditions. One such achievement of the rubber manufacturing industry is the development of Neoprene compositions for use at subnormal temperatures.

Neoprene seals, valve inserts and similar items have made high performance records where oils, hydraulic fluids, dust, mud or grit are encountered. This synthetic has been found particularly useful in meeting the severe requirements of oil-well drilling equipment. Here gritty mud, flowing at high speed, can wear out high-grade steel parts in an amazingly short time. Neoprene valve inserts, acting both as a seat and a seal in high pressure and pumps for rotary drilling rigs, have greatly reduced the frequency of repairs and the amount of lost time. One mud pump valve was used in the drilling of five Texas wells, averaging more than 10,000 feet in depth, before it had to be replaced. This was approximately five times the service life of the usual valve. When inserts are subjected to oil, which often happens in well-drilling practice, rubwill soften and wear away rapidly, while Neoprene remains practically unaffected. Neoprene casing guards and wipers for rotary drill stems have proven highly satisfactory.

Neoprene multi-seal rings have been a key feature of the flexible couplings used in many pipe lines carrying oil, gasoline or other fluids or gases. Couplings of this type are specified in areas where earthquakes, landslides, washouts and explosions would make rigid connections unsatisfactory. In one such area a thirty mile test gasoline line was installed, using several hundred thousand Neoprene rings.

Illustrating the value of Neoprene in low temperature assignments in the use of seven different Neoprene seals, each designed for a specific job, in the mechanism controlling the variable-pitch propellor in certain aircraft. This hydraulically-operated full-feathering control equipment posed many difficult design problems. Not the least was the necessity for seals to hold oil under pressures varying from 50 to 400 lb. per. sq. in. The seals operate under varying clearances because of the different expansion coefficients of the several alloys used in the mechanism; and they must function satisfactorily through a temperature range of —50 to 150 deg. F.

Special clamps for holding airplane hydraulic lines and electric conduits in place and cushioning them against viabration are made with a Neoprene pad firmly bonded to the metal base by a "Thermo-welding" process. Neoprene was chosen not only because of its vibration-absorbing property but because of its resistance to hydraulic fluid, gasoline, and oil, and its stability under severe temperature changes. A special composition is used which is electrically conductive and will not permit static charges to build up.

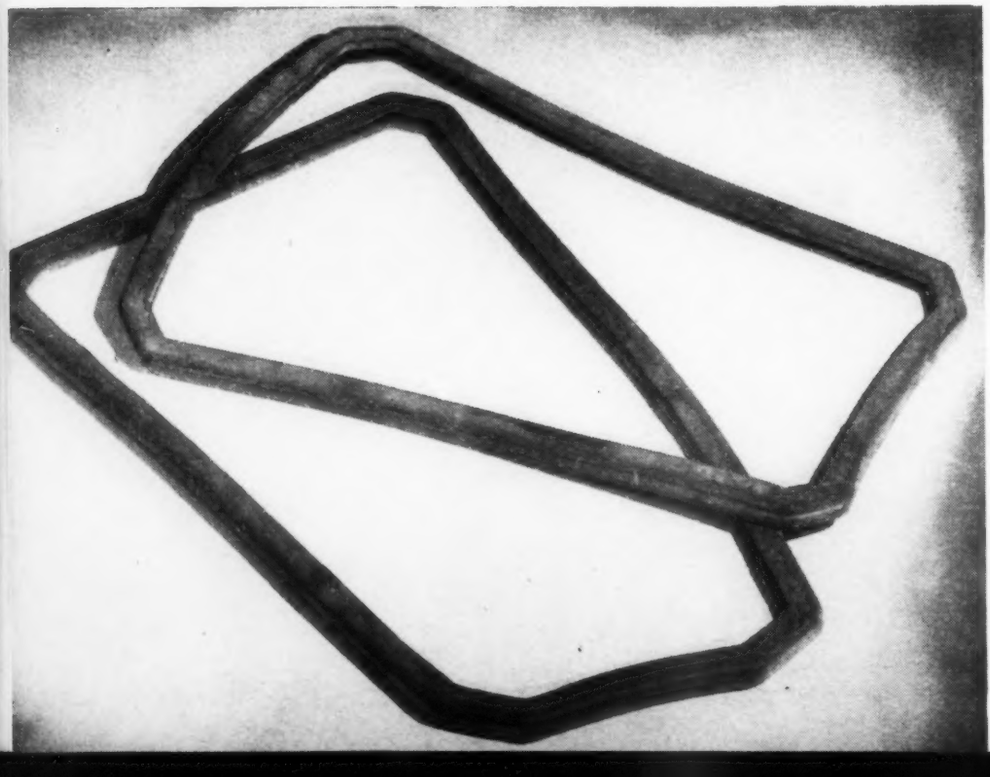
Among other applications utilizing vibration-absorbing properties are flexible bearings or bushings, consisting of a Neoprene member held between two concentric metal tubes. Here again, oil resistance is a distinct advantage. Automobile engineers use Neoprene for motor mounts, as well as for dust and grease seals, gaskets, diaphrams, etc. There were more than 120 Neoprene parts in 1941 passenger automobiles.

The superior abrasion resistance of Neoprene in the presence of oil, gasoline or grease has made it highly desirable for such additional applications as jacketing for electric extension cords in garages and machine shops, tires for industrial truck wheels and casters, floor matting, and pneumatic drill hose in mines and quarries.

Neoprene is useful to the design engineer not only in the form of molded products but as a fabric coating or impregnating material, as sheeting, and as a protective paint applied from water dispersions or solvent solutions. A sealing tape coated and impregnated with Neoprene has been extensively employed to make water-tight riveted seams in ships and flying boats, and to inhibit oxidation where dissimilar metals are joined. Superior resistance to the action of chemicals, including even hydrofluoric acid, has led to the use of Neoprene for lining vessels and tanks, or coating air ducts, fan rotors, etc. In some installations it is practical to apply the Neoprene, by tailoring from unvulcanized sheets and vulcanizing. In other work Neoprene in a solvent dispersion may be brushed on, and smaller parts may be dipped in Neoprene latex solutions. More viscous solvent solutions, the consistency of putty, may be laid on with a trowel and are particularly useful in repairing breaks in lead linings or in covering sharp corners.

Neoprene sheeting a thirty-second of an inch thick is being used as a time-and cost-saving substitute for grease on the stretch presses in a large aircraft plant. The elastic "lubricant" is placed on the forming blocks under the metal sheets, which are then pulled and drawn into shape for parts of the airplane "skin." This technique, by obviating the need for grease, eliminates most of the cleaning of sheets and tools and has resulted in increased production, the manufacturer has reported.

Fig. 5—Window sealing gaskets, a typical application of Neoprene rubber.



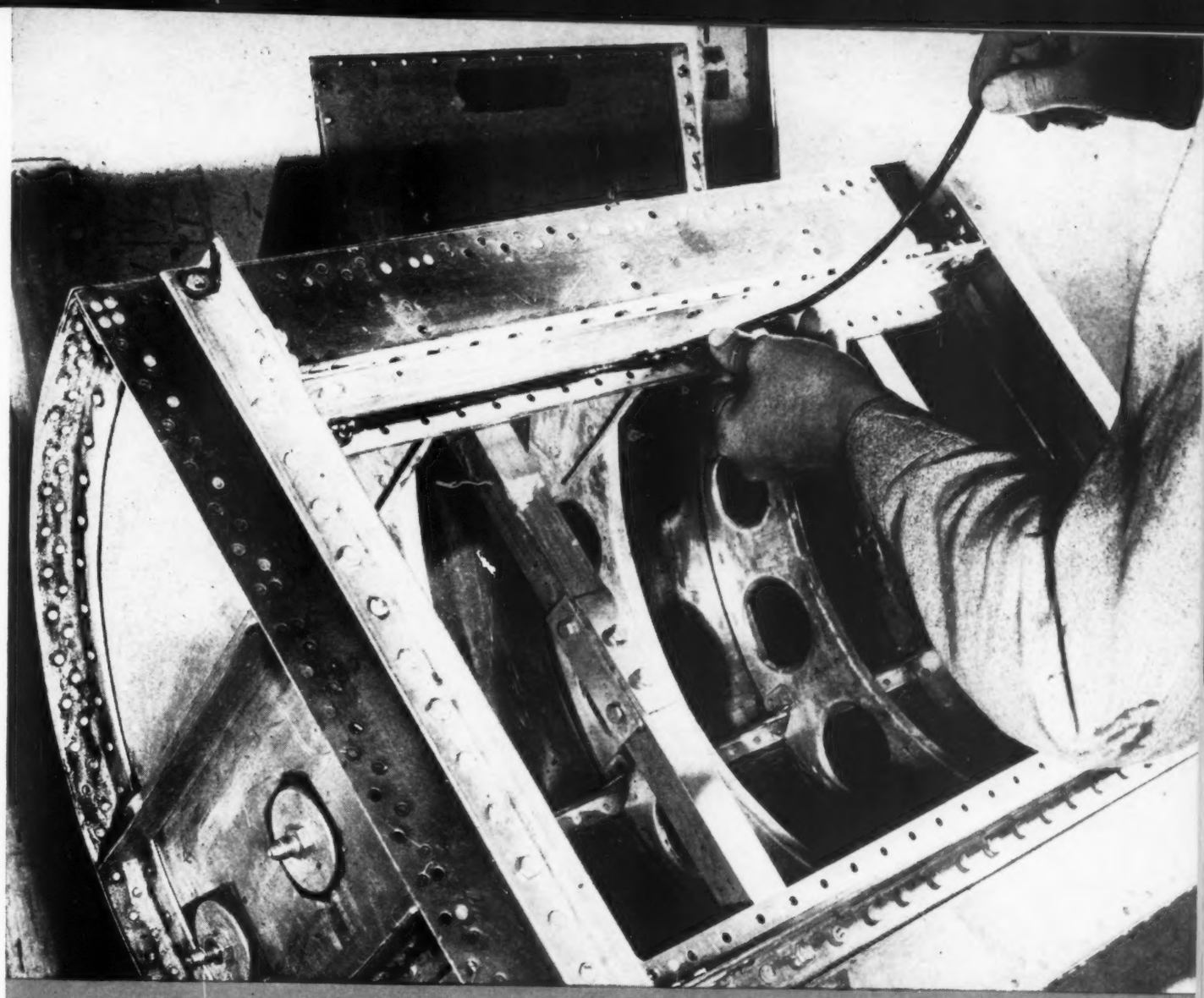


Fig. 1—Thiokol FA putty is used for caulking fuel tank seams.

Polysulfide Synthetic Rubbers

S. M. MARTIN, JR.

Manager, Sales and Technical Service, Thiokol Corporation

THE THIOKOL SYNTHETICS include synthetic rubbers, molding powders, liquid polymers, water dispersions, and rubber chemicals. Of these, the most interesting to engineers are perhaps the synthetic rubbers, molding powders, and liquid polymers which, with the exception of the molding powders, are supplied as raw materials to rubber companies for compounding, processing, and vulcanizing into finished forms. At the present time, there are three types in regular production: Types *A*, *FA*, and *ST*. Each differs from the other in some important respect and should be looked upon as a special-purpose crude designed for specific uses. Through the "Thiokol" reaction it is possible to make many different polymers with properties modified within limits to meet certain needs. At present, a special polymer is being made on pilot-plant scale to meet requirements of low swell and extremely low temperatures without the use of volatile plasticizers.

In general, the polysulfide synthetic rubbers possess the following characteristics. The degree of swell in gasoline, aromatic blended gasoline, oils and solvents is low. They are stable to atmospheric oxidation, sunlight and ozone and, with the exception of Type A, they have good low-temperature characteristics without the use of plasticizers. They are capable of compounding to tensile strength in the 750 to 1,800 lb. per sq. in. range and elongations from 200 to 700 percent at break. Such compounds fall within the elongation and tensile range of most stocks used in mechanical rubber goods. The tear resistance and flexing characteristics are adequate for most applications. Differences of the three types of rubbers now being produced are as follows:

TYPE A gives stocks with good resistance to deterioration and swell by all solvents including straight benzene and chlorinated

Fig. 2—Fuel storage cell, of Thiokol rubber, collapsed without housing.

Table I—General Physical Properties of ST Compounds

In Hardnesses from 40 to 90 Shore

Grade No.	ASTM Hardness Number	Duro Hardness	Tensile min., lb. per sq. in.	Elongation min., percent	Comp. Set 22 hr. at 158 deg. F. max., percent	Oven Aged 70 hr. at 212 deg. F.			Liquid Aged (1) 70 hr. at 212 deg. F.		
						Change in Tensile, percent	Change in Elong., percent	Change in Duro	Change in Volume, percent	Change in Tensile percent	Change in Durometer
SA-405	105±15	40±5	500	350	65	−20	−50	+15	−3to+15	−20	−5to+10
SA-507	75±10	50±5	700	350	60	−20	−50	+15	−3to+15	−30	−5to+10
SA-610	55±8	60±5	1000	300	60	−20	−50	+15	−3to+15	−30	−5to+10
SA-706	40±7	70±5	600	200	60	−20	−50	+15	−5to+15	−30	−5to+10
SA-710	40±7	70±5	1000	200	60	−20	−50	+15	−5to+15	−30	−5to+10
SA-810	28±7	80±5	1000	200	50	−20	−40	+10	−5to+15	−20	−5to+5
SA-910	13±7	90±5	1000	100	50	−20	−40	+5	−5to+15	−20	−5to+5

Note: All compounds will pass ASTM Freeze test at −55 deg. F.
(1) Medium used is rubber process oil with an aniline point of 158 deg. F. and Saybolt Universal vicsosity of 155±5 sec. at 100 deg. F.

hydrocarbons. Principal shortcomings are poor oder, relatively poor resistance to low temperatures (0 deg. F), and poor resistance to compression set. This limits its applications to those where low temperatures are not encountered and compression set is not a factor.

Type FA possesses good resistance to a large range of organic solvents normally encountered in commerce. It has better low temperature resistance than does Type A but has poor resistance to compression set. *FA* can be softened with a chemical plasticizer to produce a rubber-like oil, grease and solvent-proof putty that remains permanently soft and can be used as a caulking material. It can also be made into coatings with suitable solvents for coating cloth or impregnating paper. Type *FA* stocks are limited to use within the temperature range of −50 to 200 deg. F in applications where compression set is not a factor. Plasticizers are not necessary for obtaining flexibility to −50 deg. F. When plasticizers are used, lower temperatures can be resisted, usually at the sacrifice of tensile strength.

Type ST is a new addition to the polysulfide line of synthetic rubbers. It possesses the same general characteristics as does *FA* as regards solvent resistance but can be vulcanized to give fair resistance to compression set. It has better low-temperature characteristics than does *FA* and is serviceable in the temperature range −60 to +200 deg. F. Since plasticizers are not required to obtain low temperature flexibility, *ST* compounds do not shrink when removed from a solvent and allowed to dry. This is an important consideration in many applications. *ST* stocks also show low swell in active solvents. In 40 percent aromatic blended gasoline, swell is around 20 percent. Because of the low-swell and low-shrinkage characteristics of this polymer, stocks compounded with it display small dimensional changes in service. Since engineers are generally interested in the properties of the crude, typical data are shown in Table I for a series of Thiokol *ST* compounds varying in hardness from 40 to 90 Durometer.

For the most part, properties of commercially produced goods will be somewhat better than those shown in the table. The data shown can be considered as suitable for specification purposes. It will be noted that while the tensile strengths of the materials are relatively low, they are adequate for most industrial applications and the fact that they maintain a relatively high percent of tensile strength after immersion in solvents means that they may actually be stronger when in service than other oil-proof rubbers showing a higher initial ten-

sile strength but suffering a greater deterioration by solvents.

In Table II is given a comparison between Thiokol *FA* and *ST* as regards a number of properties important to the engineer. This table also gives information on the resistance of these polymers to atmospheric deterioration and solvents.

Table II—General Properties

	Type FA	Type ST
Solvent resistance	See below	See below
Low temperature resistance	−45 deg. F.	−60 deg. F.
Change in brittle point after extraction	None	None
Max. service temperature	180 deg. F.	250 deg. F.
Flexibility	Good	Good
Resilience	Good	Good
Abrasion resistance	Good	Good
Natural aging	Excellent	Excellent
Sunlight resistance	Excellent	Excellent
Ozone resistance	Excellent	Excellent
Gas diffusion	Low	Low
Plastic flow	Poor	Good
Volume Swell: After 6 months at room temperature:		
Mineral Oil	1.0%	2.5%
Diesel fuel oil	1.0	1.0
Lubricating oil	1.0	3.0
Gasoline	3.0	2.5
SR-10	2.0	2.0
40% Aromatic fuel	12.0	15.0
Kerosene	2.0	2.5
Turpentine	....	2.5
Linseed oil	1.0	1.5
Acetone	20.0	37.0
Methyl ethyl ketone	18.0	49.0
Ethyl acetate	17.0	35.0
Carbon tetrachloride	40.0	48.0
Denatured alcohol	5.0	5.0
Isopropyl alcohol	3.0	2.0

Applications

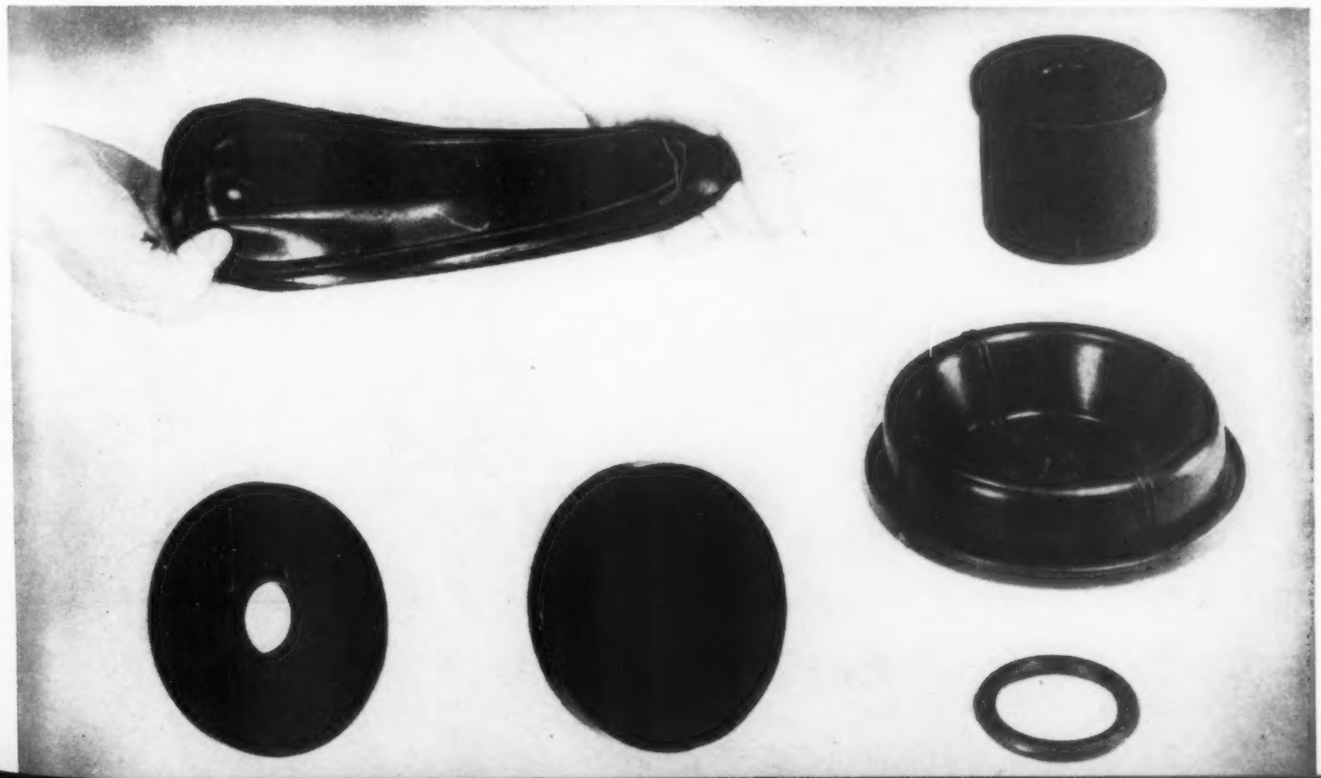
The use of Thiokol synthetic rubber in paint spray hose dates back to around 1929. It was selected for this use because of its resistance to all types of oils, solvents and thinners normally used in the formulation of paints and lacquers. It is used for the same reason in gaskets and seals for paint spray equipment. Thiokol *ST* is perhaps more applicable to gaskets and seals than is *FA* because of its better resistance to compression set. Polysulfide rubbers are used in hose of various kinds ranging from 1/2 in. in diameter up to cargo hose running 10 in. in diameter. Such hose is satisfactory for handling the general run of oils and solvents. Special hose can be built for handling the more active solvents such as benzene and other aromatics. In addition to possessing resistance to deterioration by solvents, Thiokol synthetic rubbers will not contaminate highly purified solvents and aviation gasoline. Since no plasticizers are required to obtain stocks with good low temperature resistance, the low temperature flexibility of hose made with this synthetic rubber does not change because of plasticizer extraction. This is important where service conditions require that the part or parts be subjected to solvents and then allowed to dry out before being used again.

The Thiokol synthetic rubbers are particularly adaptable to coating and impregnating felts and fabrics for a wide diversity of uses where resistance to oils, greases and solvents is a factor. These uses extend from the manufacture of high grade newspaper blankets, diaphragms and gaskets to the use of the coated fabrics for the construction of large scale cells or tanks for gasoline.

Polysulphide rubber can be molded into sheets of thin to thick gage and into intricate parts. Thiokol *ST* is utilized in numerous molded goods where low swell and no shrinkage on drying are required. Such an example is its use in gasoline selector valve O-rings or gaskets. Here, high swell in the fuel would cause binding or wedging of the valve. If the ring shrinks when it dries out, the valve will leak when gasoline is again pumped through it.

The Thiokol synthetic rubbers are suit-

Fig. 3—Typical industrial parts molded of Thiokol rubber.



able for use in printing and lacquer rolls because they are resistance to high swell in the inks and lacquer solvents. To get rolls below about 40 durometer plasticizers must be used. In order to overcome shrinkage caused by extraction, it is possible to use some "swelling rubber" in the mix.

Gaskets may be of various types and compositions ranging from pure metals such as lead and copper through asbestos and wood pulp paper to cork and cork compositions through rubber and rubber coated fabrics. The selection of the proper gasket depends on the service to be performed. The Thiokol synthetic rubbers, particularly Type *ST*, lend themselves to use in gaskets when the temperature range to be covered extends from −60 to +200 deg. F. In special applications gasket stocks have been used at considerably higher temperatures. The advantages of such gaskets are their resistance to solvents and oils and the fact that they do a good sealing job.

Type *FA* can be used as a base for oil proof sealants, either as a putty or as an extruded tape. Such sealing compounds are suitable for leakproofing the seams in gasoline tanks and the seams in pressurized cabins. Here a sealant that will remain permanently flexible is required.

Liquid Polymers

In addition to the crude synthetic rubbers manufactured through the polysulfide reaction, liquid polymers are now in production. These polymers contain no volatile or inert solvents. They are 100 percent reactive organic compounds and can be transformed from liquid into a tough resilient solid without shrinkage through the use of curing agents. Such products offer the advantage of giving flexible caulking, filleting, impregnating compositions.

Recent new work has led to the development of molding powders that are thermoplastic as supplied, but when molded at 300 to 360 deg. F. become thermoset or vulcanized. After molding, the composition is a tough, resilient elastic solid possessing the physical properties of vulcanized rubber but having, in addition, excellent resistance to solvents, oils, greases, fuels, sunlight, ozone, and atmospheric oxidation. These compounds remain flexible at temperatures below −50 deg. F. and are serviceable to temperatures in excess of 220 deg. F.

The properties of the finished compounds can be varied over a wide range of hardnesses through compounding but, for the present, molding powder is being manufactured at a hardness of 60±5 as measured by the Shore Durometer. Since the best properties are developed through the use of carbon black as a reinforcing pigment, the compounds are black in color.

In considering the properties of parts molded from this powder, they should be thought of in terms of soft vulcanized rubber and not in terms of hard rigid plastics. For example, rigid plastics display tensile strengths of from 1,000 to 10,000 lb. per. sq. in. with elongations up to 1 percent, while soft rubber goods fall within the tensile range of 200 to 3,000 lb. per. sq. in. with elongations of from 100 to 1,000 percent. The physical properties of the compounds shown are within the range normally considered satisfactory for most rubber mechanical goods applications.

In general, the physical properties of parts molded from these powders can be arrived at from the data shown in the tables below. Table III summarizes properties obtained from 610 molding powder. Table IV gives the characteristics of the powder as supplied.

Table III—Properties of Parts Molded from Thiokol Molding Powder MF 610

Hardness (Shore Durometer)		60±5
Tensile Strength, lb. per sq. in.		1,000
Elongation at break, percent		400
Brittle point, deg. F.		−60 deg. F.
Maximum service temperature, deg. F.		250 deg.
Resistance to abrasion		Good
Resistance to sunlight		Excellent
Resistance to ultra violet light		Excellent
Resistance to ozone		Excellent
Volume swell in:	Mineral oil	2.5%
	Gasoline	3.0
	Aromatic gasoline (1)	16.0
	Kerosene	2.5
	Turpentine	2.5
	Linseed oil	1.0
	Ethyl alcohol	5.0
	Acetone	37.0
	Carbon tetra chloride	48.0

(1) Aromatic gasoline consisted of 60 percent aviation gasoline, 20 percent Toluol, 15 percent Xylol and 5 percent Benzol.

Fig. 4—Spraying oil- and gasoline-resistant Thiokol *FA* rubber on metal.

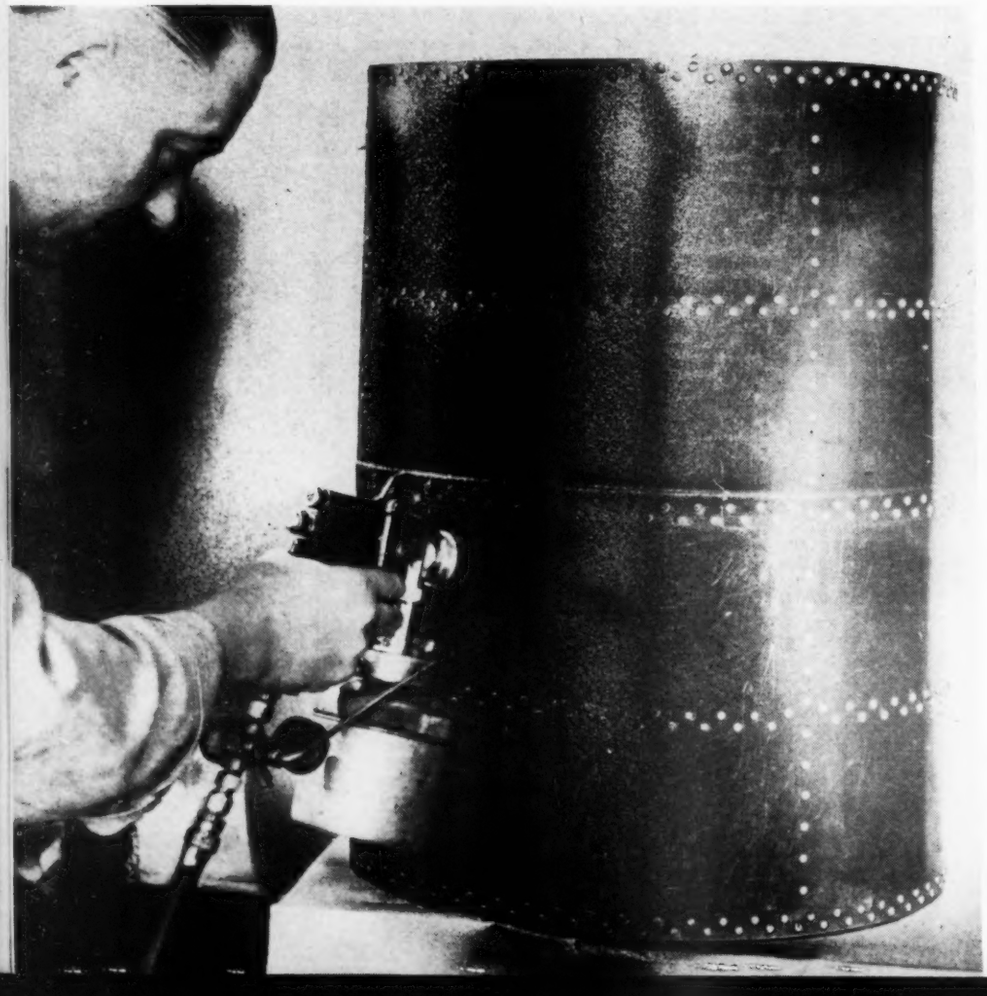
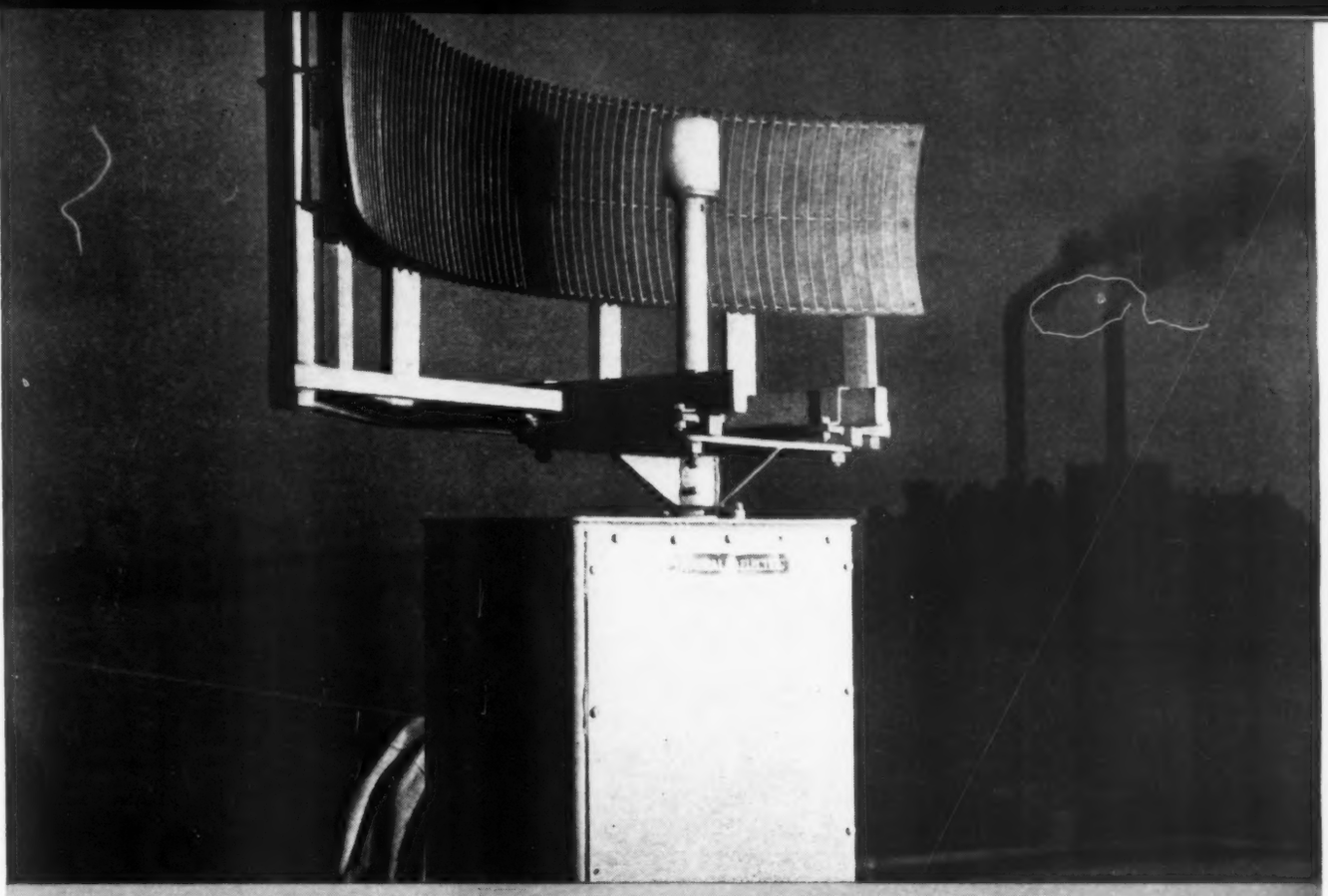


Table IV—Properties of MF 610 Molding Powder

Specific gravity	1.48
Bulk Factor ± 0.25	3.00
Molding temperature	320–360 deg. F.
Molding Time (minutes)	3–10
Shrinkage (inches per inch)	0.020
Weight per cubic inch (oz.)	0.86



Antenna is mounted high above the top deck of the "American Mariner". Small size and compact assembly of antenna, compared to huge "bedsprings" of military sets, should be noted.

Electronic Marine Navigator First Commercial Radar Product

Radar enters the postwar commercial market in the form of a marine navigation aid. Design and method of operation are described.

FIRST COMMERCIAL application of radar to be marketed, an "Electronic Navigator," for use as an obstacle detector and in shoreline navigation, was recently announced by the General Electric Company. Being offered for sale by G.E. to merchant ship owners and operators, the unit furnishes one answer to the question: What practical applications would come out of the wartime electronics development of radar?

It is evident to anyone who has seen the unit in action, that it is not a hurriedly-assembled piece of equipment being sold to "catch" the hungry postwar market, but rather a carefully designed, thoroughly tested instrument, developed to fill a specific need.

Working quietly, G.E. had been experimenting with this application since June of 1943. At that time, the company requested, and received, permission from the Navy to install a radar unit in an ore-carrier, which was then navigated in the Great Lakes. What they started with was a military radar set, and after about five months of testing, consulting ship operators as to their needs, and making changes constantly, the "navigator" began to take shape.

It was at this point that the "tube and circuit" specialists of the Electronics Department in Schenectady came into the picture. Realizing that their postwar bread-and-butter lay in good marketable products, and having their days filled with war research, these men worked evenings and Sundays at perfecting the Navigator. New circuits were required if a radar set simple enough for civilian use was to be hatched out.

First practicable model of the Navigator, or EN-1C, as it is designated by G.E., was completed last June, and since then has been tested continuously on a Maritime Service training vessel, the "American Mariner," which has been plying East Coast waters. With the aid of personal observations made by Vice Admiral H. L. Vickerey, U. S. N., Vice Chairman of the U. S. Maritime Commission and Capt. J. H. Masse, U. S. M. S., skipper of the vessel, a number of changes were made, and then demonstrations to prospective users were begun, soon after V-J Day.

Different from military and naval radar units (see radar article in October "Industry and Societies") in several respects, EN-1C is as uncomplicated to operate as a home radio set. Unlike many military radar detectors, which have separate azimuth, elevation and range transmitters and antennas, the navigator has a single, small antenna which both sends out ultra-high-frequency

impulses and receives the "echoes" reflected from nearby objects. The navigator has been "boiled down" to bare essentials, and specializes in surface search.

The small antenna, backed up by a parabolic reflector, is usually mounted at the highest point on the ship, although this is not always necessary. Sending out a beam which is 5 deg. wide in the horizontal plane, but encompassing a 15-degree spread in the vertical plane (about 7½ deg. above, and 7½ deg. below, a line drawn horizontally from the antenna), the antenna rotates at a constant speed of eleven revolutions per minute, giving a 360-degree sweep of surrounding waters once every six seconds.

Impulses received by the antenna are carried to the console in the wheelhouse by means of either coaxial cable, or waveguide, a rectangular hollow conductor, which is a recent development in the transmission of microwaves. With waveguide or coaxial cable, microwaves can be carried around corners, or in twisted paths. Focusing of microwaves, in much the same way that light is focused, is accomplished in the navigator with the aid of coaxial and the parabolic reflector.

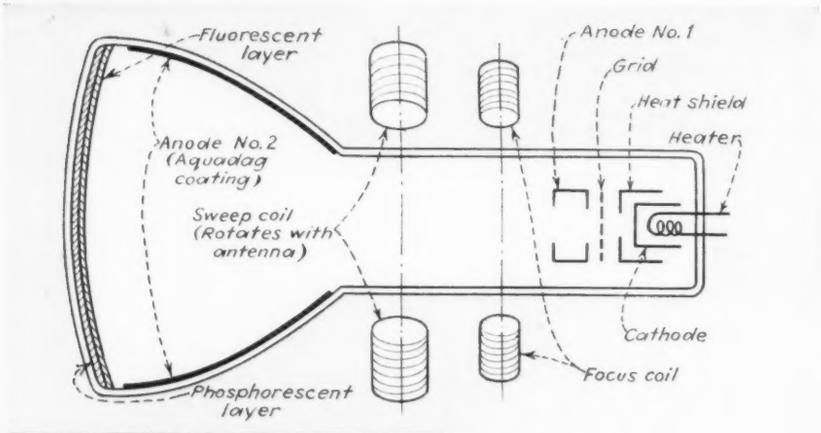
Understanding of electronic principles is not necessary for the operator, who merely stands at the console, and manipulates several simple controls. An on-off switch starts the antenna rotating, and the pulse-sending mechanism. Another control gives the operator a choice of three ranges, corresponding to the radius of the area visible in the screen: 2, 6, and 30 miles. Another switch makes visible "marker" circles—equidistant, concentric circles which aid in making rapid estimates of the distance of obstacles from the ship. Two more knobs control the amount of light coming from the fluorescent screen, and the sensitivity of the receiving circuits. The latter is analogous to the volume control on a home radio, enabling the operator to distinguish between small and large objects that are close together.

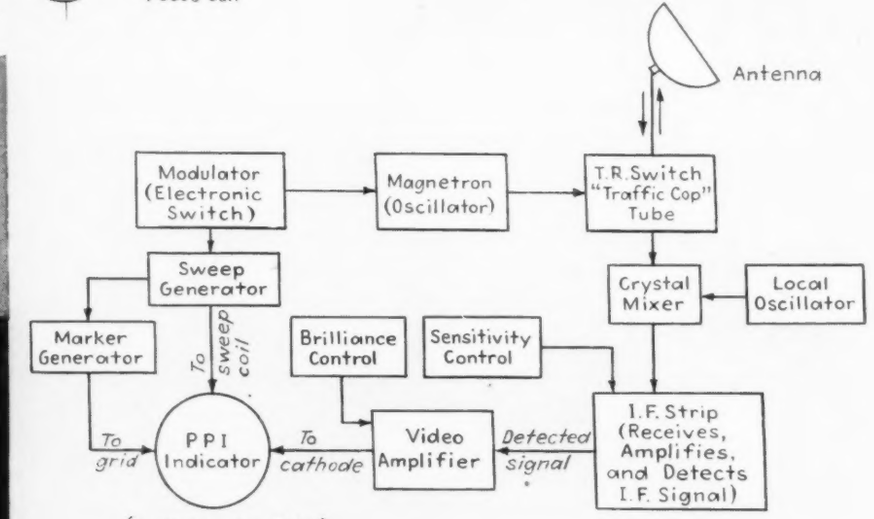
When the echo of an obstacle appears on the screen, the operator moves a lucite disk which has a radial line engraved on it, and locates the obstacle by making the line coincide with it. A 360-deg. azimuth scale around the screen enables the operator to determine the bearing of the object in relation to the ship's course, or to true north, whichever is preferred by the ship's captain.

A motor-generator set, which is small in size and can be mounted in any convenient space, is connected to the ship's d.c. lines and furnishes 110-volt a.c. which is later transformed and rectified into the low-voltage and high-voltage d.c. needed for operating the Navigator. In order to best understand how the unit operates, however, the reader should refer to the block diagram, without considering power sources.

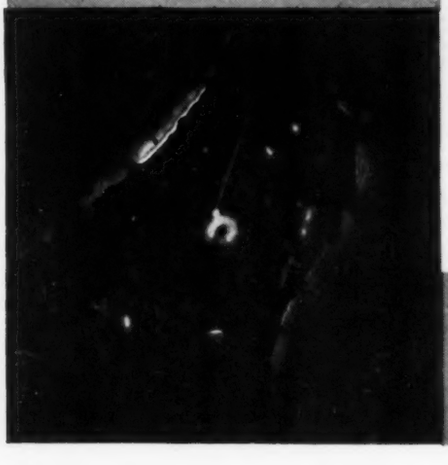
The modulator, which may be thought of as an electronic switch or "timer," amplifies the radar pulses, produced by a "blocking oscillator." The modulator drives the magnetron, which is an oscillator tube producing ultra-high-radio-frequency current. At a wavelength of 10 cm., the "broadcast" frequency is 3,000 megacycles. The modulator, acting as a switch, permits this high-frequency power to be produced by the magnetron (transmitter) in short spurts—with much longer intervals of time occurring between the spurts or pulses. About 1,000 of these cycles—pulse and time interval—per second are produced by the modulator.

The ultra-high-frequency pulsed current must pass through the "T. R. Switch." This transmit-receiver, or "traffic-cop," tube acts in much the same way as a valve. It allows the outgoing pulses to pass through to the antenna, but only returns the reflected impulse which is received by the antenna into the circuit (right side of block diagram)





Block diagram of the "Electronic Navigator" circuit. Detail of PPI tube is shown. See accompanying article for explanation of the tube and circuit.



(Left) Viewing scope while the "American Mariner" was in New York harbor. Light portion at center is the ship; large dots are other ships, tiny ones buoys and small craft. Outlines of Brooklyn and Staten Island are easily seen. White line is the "lubber line."

during the time interval in which the outgoing impulse is *not* being sent. This tube also prevents the transmitted power from entering the receiver. At the same time, a small or "local" oscillator tube sets up a steady signal, of different frequency than the signal coming from the antenna. Both of these signals are fed simultaneously into a crystal "mixer," which is a mechanism for combining frequencies. The signal coming from the "mixer," is 30 megacycles and is called the "intermediate frequency."

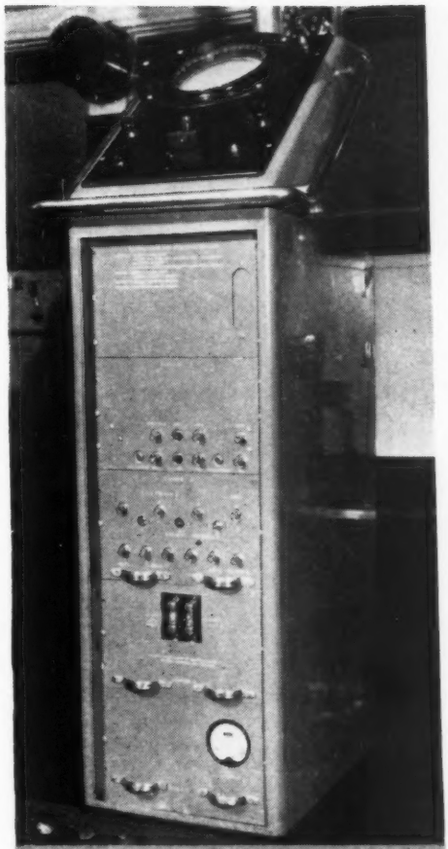
The "intermediate frequency" signal then travels into an i.-f. "strip," actually a 9 tube receiving set, which is a mechanism for picking out the combination of frequencies that it wants. Here the signal is amplified and then rectified in a detector tube. Further amplification occurs in the video amplifier, which builds up those signals having frequencies from 150 cycles to 2 megacycles.

At the same time, the modulator operates the sweep and marker generators. The sweep generator applies a "sawtooth" wave shape across the rotating sweepcoil about the cathode ray tube. This coil revolves at the same speed as the antenna, and, by its magnetic action, deflects the beam of electrons being emitted from the cathode in such a manner as to form a revolving radial line of light on the screen of the cathode ray tube. The beam travels from the center of the screen out to the edge in a time proportional to that taken by the radar signals to travel to the target and back. The sweep generator "snaps" the beam back instantly, after it has reached the edge. The "sawtooth" wave shape is that produced by plotting this motion against time.

The marker generator sends out a video signal similar to the "echo" in the same time that the transmitted signal travels to, and returns from, a target which is a specified distance away. Similar signals are produced for any other specified distance. Since these video signals are produced each time that the transmitter operates, a ring is formed on the face of the tube—these rings are the marker circles. This principle of producing concentric marker circles is the same for the 2, 6, and 30 mile ranges.

The PPI Indicator, or cathode ray tube, is the mechanism for translating the electrical signal coming from the video amplifier into a "picture" which indicates directly where surrounding objects are. It should be noted that the PPI, or Plan Position Indicator (see page 702 of the October issue of PRODUCT ENGINEERING) is not quite the same as the oscilloscope tube, although both are cathode ray tubes. The oscilloscope gives a wave form which must be interpreted, but the PPI furnishes a direct-reading chart.

As can be seen in the diagram, electrons are emitted from a heated cathode. A set of anode plates, carrying a positive charge, are in close proximity to the path that the electrons must follow, and accelerate their motion. Between the cathode and these anode plates (labeled "Anode No. 1") is a cylindrical grid which carries a negative charge. The marker generator controls the voltage on the grid, thereby producing the "marker" circles. The same number of equidistant circles are not produced for each range: There are 2 circles for the 2-mile range, and 3 circles each for the 6-mile and 30-mile ranges.



Console of the Navigator. Front cover has been removed and panels of the five chassis can be seen. Top, inclined panel containing viewing screen and control knobs is visible.

Returning to the cathode ray tube, we can see two coils above the second anode. The Focus coil forms a magnetic field inside the tube, forcing the wide beam which would result from the repulsion of like particles (electrons) into a narrow beam, forming a sharp spot of light on the center of the screen. The sweep coil operates in the manner explained previously. A voltage is applied to the cathode during the time that the beam travels from the center of the screen out to the edge. On the "return trip," the sweep generator removes this voltage, so that the returning beam is not visible.

On the inside surface of the curved part of the tube a conducting coating ("Aquadag") made of colloidal graphite, is applied. This is the "second anode" and carries a high voltage for further acceleration of the electron beam. (See diagram of tube.)

The signal coming from the video amplifier is applied to the cathode. This serves to vary the intensity of the electron beam, corresponding to the reflected pulses "caught" by the antenna. Thus, as the beam of electrons, controlled by the sweep coil, shows up as a revolving, radial line of light on the PPI screen, blobs of light—corresponding to the varying intensity of the electron beam—indicate their actual positions in surrounding waters.

The PPI screen consists of two layers; one is fluorescent, the other phosphorescent. The fluorescent is the inside layer and is excited by the electrons, giving off visible light waves. This light is of extremely short duration, however. For this reason, a second, phosphorescent layer, is applied, just inside the surface of the tube. The light from the fluorescent layer causes a light emission from the phosphorescent material which is of long "persistence." Any picture which is formed persists for about 20 seconds, but since it is re-excited every six seconds, it is always visible while it is in operating range. The observer sees a changing picture of surrounding waters, with the sweep line leaving a "trail" of new objects as it revolves.

Brilliance, or level of light intensity, is controlled from the cathode circuit through the video amplifier, by a panel control. Sensitivity, or sharpness of the images, is a separate control operating through i.-f. strip. Thus the observer can adjust the picture to suit varying combinations of targets and different degrees of wheel house illumination. For daytime use, a hood is furnished to eliminate stray light.

The screen, which is the "end" of the cathode ray tube, is covered by three lucite dials. The bottom dial, closest to the tube, is made from a special shade of yellow transparent lucite. This dial is fixed and is dimly edge-lighted. A radial line engraved in one surface, indicates the "lubber line," or fore-and-aft line of the ship. The center dial, which is movable, has a line for locating the direction of the object. The top dial, also moveable, has another line which can be set to true north, or ship's course. Thus the bearing of any object on the screen can be instantly determined, with the aid of a 360 degree scale around the perimeter of the top dial.

The console, containing five chassis, the antenna, and a motor-generator set to furnish low and high voltages, are included in the sale price of $5,950. Each of the three basic parts weighs approximately 250 pounds. Although the present price is f.o.b. Schenectady, G.E. is establishing sales and service stations for the navigator at Lake East Coast, Gulf and West Coast ports. A feature of the unit is the fact that each chassis is easily removable; it is planned to offer separate chassis, in addition to spare parts. Thus, if trouble develops in one part of the unit, the chassis in which the breakdown occurs can be replaced with a new one.

INDUSTRY AND SOCIETIES

RESEARCH—STANDARDS—PATENTS

Electronic Warfare: Radar Countermeasures

"The new eyes which radar has supplied can sometimes be blinded by new scientific developments."
—DR. VANNEVAR BUSH

IN A JOINT RELEASE by the Army, Navy and the Office of Scientific Research and Development, another war secret—electronic warfare—is revealed. Overshadowed only by the weapon of radar itself, the imagination is staggered by the vast amount of energy, electromagnetic and human, expended in blotting out the enemy's radar sets.

Several weaknesses of radar lent themselves to exploitation, both by the Germans and the Allies. An examination of these weaknesses will prove useful in discussing the counter-radar devices which were developed during the war.

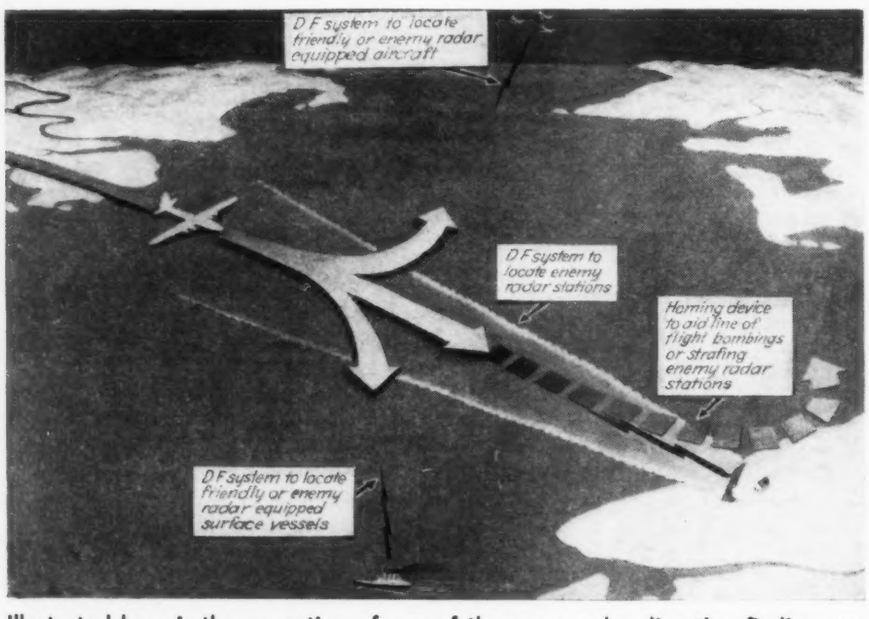
Radar stations sent out radio impulses of tremendous strength; all that is needed to detect these signals is a special receiver which can tune to the extremely short wavelength used by radar. This represents the first weakness of radio location. Second, a radar set betrays not only its existence, but also its exact location. A radio direction finder makes it possible to determine the direction from which the signal is coming.

A third weakness of radar sets is the fact that the echo returned from most targets is weak in strength. The sound returned from the cliff is many times weaker than the man's original shout. A fairly weak noise, therefore, would suffice to cover up the echo. A second man, standing on the cliff and shouting continuously, would prevent the first man from hearing his own echo.

Radars can be blinded in the same way. It is only necessary to provide the target with a device which sends out a radio signal capable of covering up the signals reflected back to the radar by the target. This process is known as electronic jamming. Because each radar set operates on a particular frequency channel, it is necessary that the jammer—which is fundamentally a small radio transmitter—be tuned to that same channel.

A practical radar jammer consists of a tunable radio transmitter provided with a type of modulation which is especially suited to drowning out radar echoes. Any home radio owner who uses an electric razor has a good idea of what such interference means. It has been found that the most effective radar jamming signal is simply a hissing noise similar to the background noise heard in sensitive radio receivers when no program is being received. Such a signal is said to have a "random noise modulation."

When picked up on a radio receiver equipped with a loudspeaker, a noise jamming signal sounds like a hiss. A radar, however, presents the information it received not aurally but visually. Signals appear as patterns on the face of a cathode-ray tube. As seen on this tube the "noise" looks like many fine blades of grass moving about in a random fashion. Echoes from airplanes, which are usually displayed as vertical spikes on the radar scope, simply disappear and become lost in the "grass."


D F system to locate friendly or enemy radar equipped aircraft
D F system to locate enemy radar stations
Homing device to aid line of flight bombings or strafing enemy radar stations
D F system to locate friendly or enemy radar equipped surface vessels

Illustrated here is the operation of one of the many radar direction finding systems, which were used in Ferrets and other aircraft for accurately determining the location of a concealed enemy radar station. As a direction finder, it was used also for navigation and homing on our own radar systems.

"Window"

A further weakness of radar sets is the circumstance that they cannot distinguish the nature of small targets. One small object, capable of returning an echo, looks to a radar just about the same as another. To a radar, an airplane or a ship is a small object. It has been found that a number of thin metallic strips, cut to a length proportional to the wave length used by a radar, can return a remarkably strong echo to that equipment. In fact, several thousands of these thin metallic strips, packaged in a small bundle weighing less than 2 ounces, will give a radar echo signal equivalent to one bomber, when the strips are ejected from a plane and allowed to fall freely through the air.

The phenomenon is one of resonance. The metallic strips, designated by the code name "Window," are resonant at the frequency of the radio waves sent out by radar; in this way a relatively small number of strips can return an echo equal to that from a large metal object such as an airplane.

If a number of Window packets are

dropped out of a plane in succession, a trail is produced in which a radar can no longer distinguish a real target. The echo from an aircraft is simply lost among the echoes from the Window. It is much as if the planes were being concealed by a smoke screen of metallic foil.

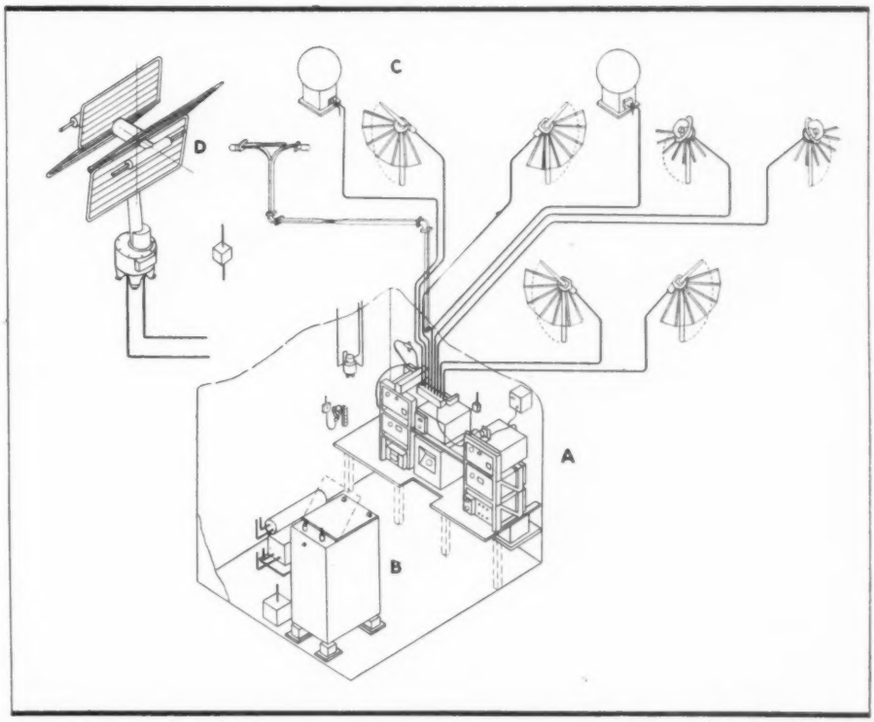
"Tuba"

Like radar itself, radar countermeasures were developed by many cooperating agencies. Most of the research on this development, however, was done at the Harvard Radio Laboratory, under Division of 15 of the National Defense Research Committee, and was financed by government funds through the Office of Scientific Research and Development.

One of the most ingenious countermeasures developed by the Harvard Laboratory was a device known as "Tuba"—a tremendously powerful jamming transmitter developed for use against German night fighters. In addition to its countermeasures applications. It was certainly one of the outstanding individual scientific achievements of the war.

The problem was to create a jamming device to blind the German night fighters, which in 1942 took a heavy toll of British night bombers. The German fighters used an air-borne interception radar known as "Lichtenstein" for close-range location of their targets. Against them the British found it impractical to use jammers carried in their bombers, because the jammer itself provided a signal which the German fighters could use to locate the bomber. A radio signal, including a jamming one, betrays the direction from which it comes and even though a jammer might blot out a German scope, making it impossible to find the range, the German could find the bomber simply by following the signal in.

But the German night fighters usually did not reach their prey until after the British bombers were flying home from their mission. Someone suggested, why not set up a very high-powered jammer in England to blind the German fighters' radar as they flew toward it in pursuit of the homeward bound bombers? It would be a blinding beam "shining" in the German "eyes" (i.e., their radar antennas)—through which the bombers could fly to their bases in safety.



U. S. Navy Photographs

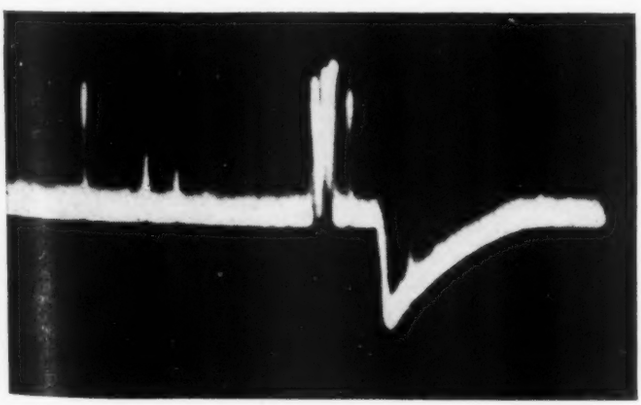
Typical radar countermeasure installation aboard ship: *A*, equipment for picking up, analyzing and determining direction of enemy radar pulses; *B*, Jamming transmitter; *C*, and *D*, antennas used in locating and jamming enemy radar.

A jammer of this sort obviously would require enormous power. It was calculated that it would need power a thousandfold more than any previously attained in the frequency range of operation involved, which in itself was 10 times higher than that used for frequency modulation and television.

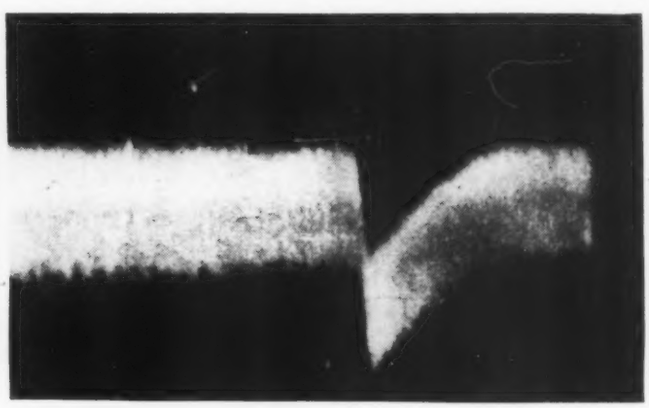
It appeared possible to solve the power problem by means of a remarkable vacuum tube, developed in the United States, known as the "Resnatron." This NDRC development, sponsored by the Signal Corps, was so promising that the British immediately placed a lend-lease order in the United States for a complete jamming system based on its use.

Since the experimental model used a huge parabolic antenna, the project was promptly nick-named "Tuba," to distinguish it from smaller projects already known as "Piccolo," "Flute," and the like.

All sorts of difficult technical problems had to be solved. It was necessary to build a



BEFORE



AFTER

These photos show what havoc "jamming" raises on a radar indicator. At left, a radar scope picks up a distant target, with the "V" notch showing the range of the object. At right, the radar installation has been jammed by a "Tuba" set, falling strips of "Window", or other countermeasure, and the image on the enemy radar scope is confused.

This odd-looking "half-cheese" antenna, part of "Tuba," is designed to give a beam very sharp in the vertical plane, and relatively broad in the horizontal plane. This antenna is unique in that it will operate over an unusually wide frequency range. The "half-cheese" is really a reflector, excited by the waveguide and horn at the bottom.

resnatron that would be tunable over a wide frequency range (because the Germans could change the frequency of their radars by slight modifications). This had been though incompatible with high power, but a tunable resnatron was produced in one of the industrial laboratories. Also it was necessary to find a way to modulate the resnatron's output with the random "noise" necessary for jamming, but this too was accomplished and by January 1944 a workable instrument had passed its test.

Its power was comparable with that of the most powerful United States broadcasting station (50,000 watts), yet the frequency of operation was 500 times as high. The whole instrument, together with all its associated equipment and its primary power generator, was loaded in seven Army trucks.

By June 1944, the complete jamming system had been shipped to England and was in operation against the enemy—a remarkable achievement when one considers that the equipment was still in the blueprint stage when work early in 1943, NDRC scientists were flown to Great Britain to help set up the equipment and train the RAF in its use.

Postwar Possibilities

There has been a steady trend, in past radio development work, in the direction of higher and higher frequencies. First came broadcast radio, then shortwave radio and finally FM. This trend has been enormously accelerated during the war by the need for radar and allied devices. However, much of the radar technique—such as the pulse-echo method itself—is highly specialized. Counter-measures development work, on the other hand, has been concerned with continuous-wave techniques similar to those used in ordinary radio communication.

The new developments embodied in the design of countermeasures equipment represent the very developments which will be needed to solve many postwar problems and to make applications possible.

Basically, much countermeasures research was directed toward the improving and development of radio transmitters and receivers of a type very similar to those which will be used in postwar FM, television, and radio relay transmission.

Design Division of A.S.M.E. Launched

NEWLY-FORMED, the Machine Design Group of the American Society of Mechanical Engineers got under way at a Machine Design Conference held at the Hotel Pennsylvania in New York on Nov. 29, during the annual meeting of the A.S.M.E. Dr. J. F. Downie Smith of the United Shoe Machinery Corp., who had been named by the A.S.M.E. Council to serve as first chairman of the design group, presided at the session.

The following members of the group were chosen to serve on the executive committee: Dr. Smith; Mr. B. P. Graves, chief engineer, Brown and Sharpe; Mr. L. F. Nenninger, chief engineer, Cincinnati Milling Machine Co.; Mr. G. F. Nordenholt, Editor PRODUCT ENGINEERING and Mr. C. Carmichael, Assoc. Editor, Machine Design. Mr. Graves was chosen secretary of the group for the following year. To handle the technical papers, a committee headed by Mr. H. Carlson, chief engineer, Lee Spring Co., was appointed.

At the conference, the history of the group, beginning with the Sept. 14 meeting in Springfield, was reviewed. Because of the late date of approval by the Professional Divisions Committee and the Council, it was realized that a technical program could not be arranged in time for the annual meeting. Since the spring meeting of the A.S.M.E. is considered too near, it was agreed to start Design Group activities at the June meeting in Detroit. Papers of interest to those working in and around Detroit were expected.

New Solder Flux Developed at Battelle

CLAIMED TO BE more effective than common rosin fluxes, a new solder flux that can be used safely in electrical equipment and can manufacturing has been developed by Battelle Memorial Institute, Columbus, Ohio. The flux, which is an organic mixture, was developed in an investigation of fluxes that could be used with low-tin solders where zinc chloride or acid fluxes are not recommended. Although the raw flux has an acid reaction, at soldering temperature neutralization occurs. Development of the new mixture was sponsored by the Tin Research Institute, whose headquarters are at Battelle.

Proximity Fuze Component Promises Peacetime Uses

READERS OF PRODUCT ENGINEERING will recall the mercury switches mentioned in the Proximity Fuze article which appeared in the "Industry and Societies" section for November. One such switch operated in the rotary type of shell by centrifugal action, throwing the mercury out through the sides of a powdered metal porous cup in order to make contact.

Dr. Paul Schwarzkopf, who was engaged by the government to establish fine control over powder metallurgical methods in order that the mercury could seep through the nickel cup in a predetermined amount of time, now brings to light the possible peacetime applications of this development. Instead of centrifugal force, pressure can be used. Thus it ought to be possible to make time delay relays which will operate in a second or longer.

The use of porous metal in filters would not be limited to the separation of solids from liquids or gases. Liquids which are immiscible such as oil and water, can also be separated in this manner. There is the hope that even emulsions can be separated, which ought to be of interest, for instance, to oil companies, whose product, sometimes intimately mixed with water, is carried for hundreds of miles through pipelines.

Porosity can also be used to control rate of flow, as in meters and other measuring instruments. Similarly it ought to be possible to add precisely the right amount of gas or liquid to a mixture. Control of the rate of flow by porous metal parts is of especial importance in jet propulsion. The nozzles of airplane jets must not be clogged by such impurities as unburned drops of oil or solid particles. A porous metal filter can sift out contaminators and keep nozzles clear.

WASHINGTON NOTES

Hearings on Science Legislation Concluded—With testimony before the joint session of the Senate Subcommittee on War Mobilization and two subcommittees of the Senate Commerce Committee considering science legislation coming to a conclusion, our national policy on federal support of technical research was far from decided. If any reason were needed, it would seem that the hearings ran out for sheer lack of witnesses.

Readers of this column are aware of the nature of the Kilgore (S. 1297) and Magnuson (S. 1285) bills, two leading contenders for passage among the five science bills now before Congress. Briefly, the Kilgore bill would set up a National Science Foundation, directed by a single man, to be appointed by the President. In the Magnuson bill, control of the foundation would be placed in the hands of a board of nationally-known and reputable scientists. Another point of difference, causing an even greater split between the proponents of each bill than the question of who shall control the federal research organization, was the patent question. The Kilgore bill would allow the Presidentially-appointed director to decide whether the government or a private firm controls patent resulting from federally-financed research; the Magnuson bill does not prescribe any patent policy, leaving each case to be decided by the controlling board.

In the month-long hearings, almost every prominent figure in pure science, engineering, public administration, social science, religion, labor, management and the armed services had testified. It was plain that only the Kilgore and Magnuson bills were being considered, although theoretically the Fulbright bill (S. 1248), which would set up a scientific research bureau in the Commerce Dept., was before the committees. The majority opinion favored the Magnuson bill; this seemed especially true of the scientists, who were fearful of losing their freedom of research.

Summary of the Testimony—Here is a tabulation of the most important questions asked at the hearings, together with the answers:

1. Should the Government sponsor research and education in Science?
116 witnesses favored government sponsorship; 1 witness suggested that the need for government sponsorship was open to question and should be thoroughly investigated.

2. Should the primary authority of the Foundation be located in a single director, appointed by the President, with an advisory board or in a Board appointed by the President which would employ and supervise its own director?
41 witnesses favored the Board; 23 witnesses favored the Director; 53 witnesses expressed no comment.

3. Should government officials be included as ex officio members of the Board or should the prerequisites of membership be solely interest and capacity in science?
33 emphasized a need for a Board appointed solely on the basis of qualifications and not on an ex officio basis; 12 recommended the inclusion of ex officio Board members; the rest made no comment.

4. Should the Government demand ownership or cancellation of all patents on inventions resulting from research financed in any part on federal funds or should the proposed National Research Foundation be free to negotiate the terms of each research contract with respect to patents without legislative restrictions?
25 witnesses favored the omission of any statutory limitations; 2 witnesses demanded that all patents, without exception, become the property of the Government and subject to a system of Government patent licensing; 15 witnesses desired all patents, with some rare exceptions to recognize the contractor's interest in the matter, to be dedicated to the public; 75 witnesses expressed no opinion.

5. Should the social sciences be included within the program of research and education to be administered by the proposed National Research Foundation?
33 witnesses favored the inclusion of social sciences; 4 witnesses opposed the inclusion; 3 witnesses expressed doubts and reservations with regard to the inclusion of the social sciences; the rest expressed no opinion.

6. Should the proposed National Research Foundation sponsor the international exchange of scientific information?
9 witnesses expressly and strongly urged adassistance and encouragement of the international aspects of science; no witness opposed the proposition.

Several times compromise Kilgore-Magnuson bills were heralded, but as many times negotiations between the leaders of both factions broke down. Latest tendencies toward a compromise are discussed later in this column. Events, however, do not wait for senatorial negotiations, and at least one group of scientists outside of Washington plainly expressed their feelings.

"We are Opposed to the Kilgore Bill"—On Nov. 26, in the handsomely-appointed board room of the A.I.E.E., located in the Engineering Societies Bldg. on West 39th St. in New York, a press conference was held. Present were, besides members of the press: Boris A. Kakhmeteff, Professor of Civil Engineering, Columbia Univ.; D. W. Bronk, Director, Johnson Research Foundation; Homer W. Smith, Professor of Physiology, New York University College of Medicine; John T. Tate, Professor of Physics, University of Minnesota and Bethuel M. Webster, Webster and Garside, New York. Signed by 43 of the nation's most prominent scientists and educators (including the aforementioned gentlemen), a statement which expressed unequivocal opposition to the Kilgore bill, and supporting the Magnuson bill, was distributed.

This august body, calling itself a *Committee Supporting the Bush Report*, and having for its chairman Isaiah Bowman, President of Johns Hopkins University, claims in its prepared statement that the fundamental principles contained in the Bush report would best be served by passage of the Magnuson bill. The statement, in the form of a letter to the President, expressed their feelings as to the differences between the two bills in eight points. Principle points of opposition to the Kilgore bill were on the questions of a single administrator and the government's control of patent policy. A long paragraph showed their opposition to inclusion of the social sciences in federal science legislation.

A well-known "popular" writer on scientific subjects asked the scientists present if it was not true that the older, more established scientists favored the Magnuson bill, while the younger men would welcome the Kilgore bill, since it would furnish a measure of economic security. The scientists replied that this was not true. While they said that they could not speak for the membership of the various technical societies to which they were affiliated, "unofficial" polls had shown that the majority of scientists of all ages favored the Magnuson bill. Headquarters of their committee is at 477 First Ave., New York 16, N. Y.

Are the Issues Clear?—At least one signer of the aforementioned statement showed by his testimony before the Senate committee that

WEATHER RADAR

As early as August, 1943, Army radar technicians, noting curious "ghost echoes", were able to attribute them to thunderstorms. This led to a study of the phenomenon, and Army weather observers soon learned how to use radar to plot storms. A violent hurricane last Sept. 15, occurring near a weather radar station, resulted in new findings about the nature of hurricanes. Throughout the hurricane the general shape of the disturbance was plainly seen on the micro-wave set, because the energy was reflected by the rain.

A high-altitude bombing radar set, designed by the Signal Corps to spread destruction in enemy countries, has also been adapted to peaceful meteorological use in detecting the approach of storms. Developed at the Signal Corps Engineering Laboratories at Bradley Beach, New Jersey, and originally installed in B-29 bombers, these sets are being dismantled and mounted in observation stations. There they foretell the direction, intensity and other characteristics of imminent weather disturbances.

When the set is in operation the intensity and distance of an approaching storm are indicated on the screen of one cathode-ray tube, the signals appearing as vertical deflections on a time scale. Another type of cathode-ray tube (Plan Position Indicator) records direction by means of glowing points of light appearing on a moving arm. The set—technically known as the AN/APQ-13—has located storms as far distant as 200 miles.

his support of the Magnuson bill was not unqualified. Dr. L. A. DuBridge, director of the Radiation Laboratory at M.I.T., expressed opposition in his testimony to section 7 (i) of the Magnuson bill, which suggests that all young scholars receiving scholarships and fellowships from the foundation be required to enroll in a National Science Reserve. Said DuBridge: "In my own case, if I had been asked to enroll in such a reserve 10 years ago, I should certainly have refused." It was not known how many other signers of the statement had read this provision of the Magnuson bill, and whether they had formulated any opinions on it.

Again, Compromise—It is definitely known that negotiations for a new compromise Kilgore-Magnuson bill have been resumed. Reported redraft proposed by Sen. Kilgore has the following new points:

(a) Organization. Provision is made for an Administrator appointed by the President, with Senate confirmation, for a six-year term, and a Deputy Administrator not confirmed by the President and with no limitation on term of office. The Advisory Board would consist of one-half other public members, all appointed for four-year terms. The Board is given two functions not strictly advisory: (1) The power to report and recommend to the President and to the Congress; and (2) The power to approve all Advisory Boards including those established to advise the several divisions of the Foundation. Advisory Board members are exempted from the usual statutory provisions governing outside interests of Federal employees, except that they may not participate in actions relating directly to their outside interests.

(b) Social Sciences. A Division of Social Sciences is established.

(c) Technology. A Division of Engineering and Technology is established. (The Kilgore group has some doubt about the advisability of including this division, but propose that it be retained until it can be ascertained what chances of passage an amended and amplified Fulbright Bill may have. If such a Fulbright Bill shows good prospects in Congressional hearings, the Division of Engineering and Technology will be dropped from this bill.

(d) Apportionment of Research Foundation. Provision has been added to apportion among the States on the basis of population one-third of the minimum of 50 percent of the Foundation funds which are set aside for non-profit institutions.

(e) Scholarship. The scholarship provision has been broadened to permit training abroad, and State quotas are to be set up for scholarships. The national science reserve idea is dropped but a register of scientific personnel is retained. Under consideration is the addition of another paragraph on scholarships which would permit the awarding of fellowships to present employees of the Federal Government for advanced scientific training and would authorize the agencies employing such employees to pay their salaries and expenses during such training.

(f) Patent Provisions. The Department of Commerce proposal has been substantially included. The general policy of public dedication of developments arising from all Federally-financed research has been retained. A revision of the "escape clause" now provides either for advance or for retroactive determinations of exceptions to this general rule and quarterly publication by all Government agencies of the exceptions which have been made.

(g) Interdepartmental Committee on Science. An interdepartmental government Committee on Science would be established, consisting of the heads of departments or agencies determined by the President as being concerned to a substantial degree with scientific activity. The committee would be concerned with the coordination and promotion of the scientific work of the Government and is empowered to make recommendations to the Foundation, other Government agencies, and to the President.

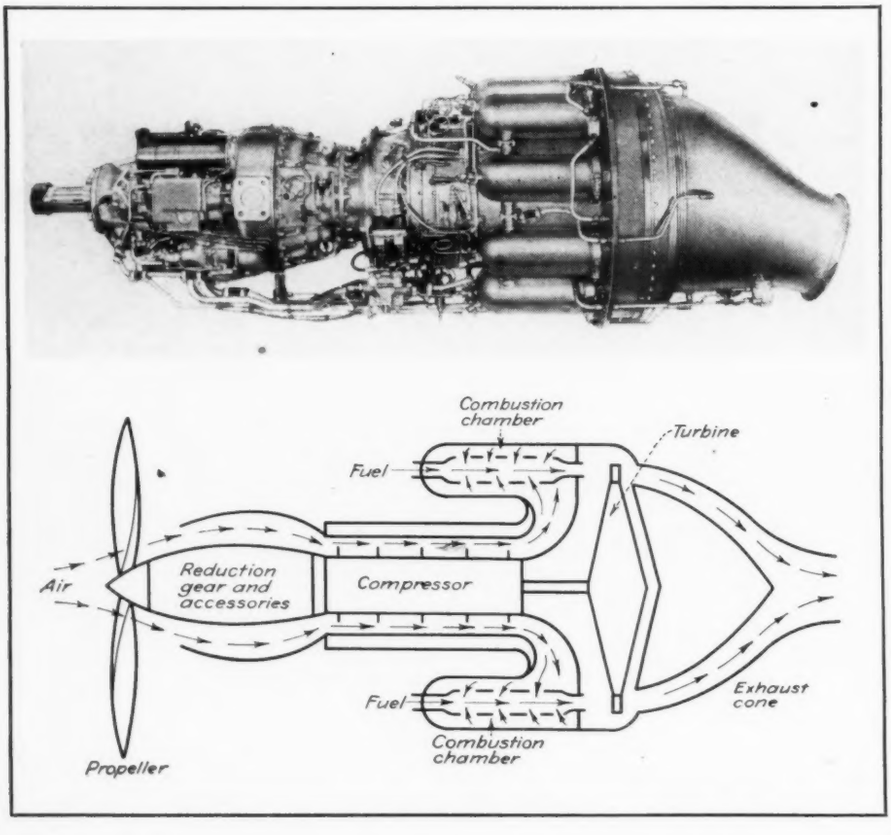
In view of the renewed support which Sen. Magnuson seems to be getting, it is an open question as to whether he will swallow this "compromise," which does not change the basic idea of the original Kilgore bill.

"Propjet" Aircraft Power Plant Announced

A NEW TYPE aircraft power plant, which through two-way harnessing of gas turbine forces drives a propeller and boosts with jet thrusts simultaneously was announced recently by General Electric Company. Designed primarily to drive large high-speed military transports and bombers, this project has been subjected to rigid test stand runs and last June was installed in an experimental Air Forces plane of advanced design.

The gas turbine with propeller is designed for installation in the wings of multi-engined aircraft or in the nose of a single-engined plane. The air rams into the nose of the project through ducts opening forward. This air is compressed by axial flow units in the forward part of the engine and then forced into combustion chambers. There fuel is injected and burns intensely. This raises the temperature and velocity of the gases, which then, with great energy, strike the buckets of the turbine wheel. The turbine, spinning more than 10,000 times a minute at a temperature over 1,500 deg. F. absorbs the major part of the energy in the gases. The turbine powers the compressor and through reduction gears drives the propeller. Reactive thrust created by the energy remaining in the gases passing through the turbine wheel and discharging rearward is utilized in jet propulsion so that the "Propjet" combines both propeller and jet power.

The power generated by these new units already is great and engineers see no basic difficulties in increasing the propulsive output of this type of gas turbine to almost any force visualized as necessary to drive the projected mammoth planes of the future.



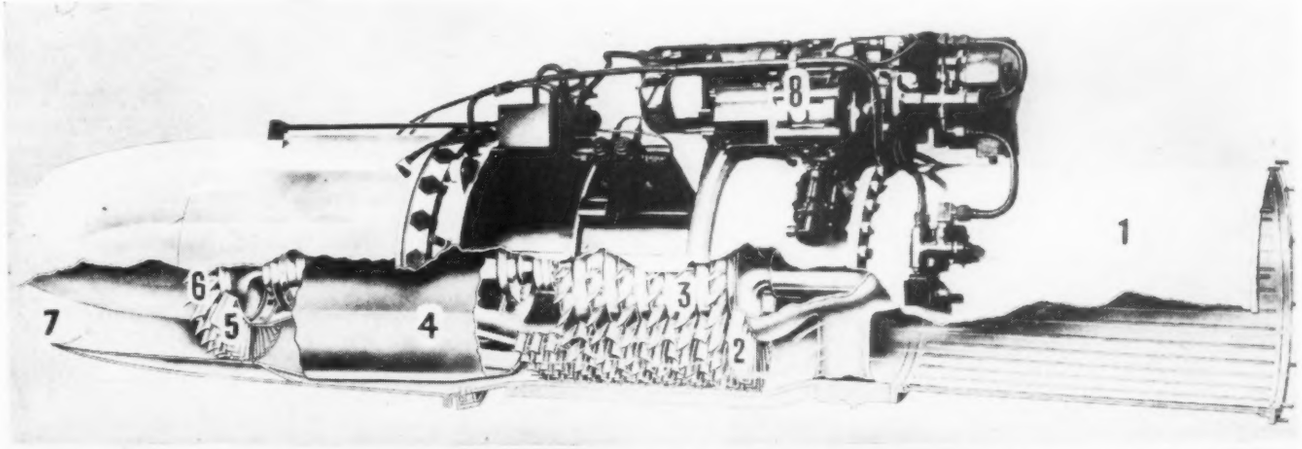
Lightest Jet Aircraft Engines in World

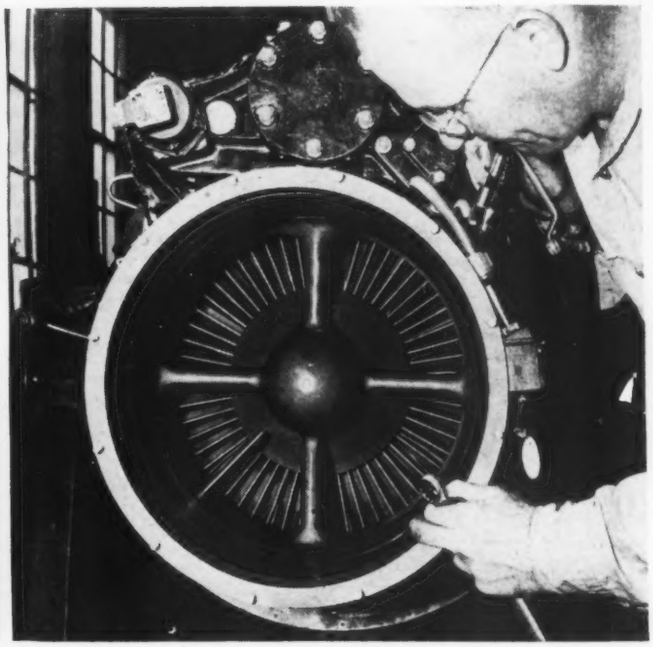
THE LIGHTEST JET aircraft engines in the world for their power and size are being built for the Navy by Westinghouse Electric Corporation. They include the "Yankee," which is 19 inches in diameter, and the "baby jet," which measures only nine and a half inches across and was developed for use in pilotless aircraft.

These engines are the first jet powerplants of wholly American design to be tested in flight. They owe their streamlined shape and light weight to the axial-flow compressor which Westinghouse's Aviation Gas Turbine Division has incorporated for the first time into a U. S.-designed and tested engine. In the axial-flow compressor, the four basic elements—the air compressor, the combustion chamber, the turbine to supply power for the compressor, and the jet nozzle—are arranged in a line, one behind the other.

Recent models of the Westinghouse "Yankee" jet have a weight of less than half a pound per pound of thrust, or less than half the weight of piston engines. The "Yankee's" total diameter of 19 inches is likewise half that of an "up-and-down" engine of comparable horsepower. The "baby jet" yields a propulsive thrust of 275 lb., or 275 hp. at modern plane speeds.

The cutaway drawing shows how comparatively slow-speed air rammed into the front of the 19B (as the "Yankee" is officially designated) jet engine is heated and expanded to yield a 1200-mile-an-hour stream of hot propulsion gases thrusting from the engine's rear (left). The engine achieved its small diameter (only 19 in.) by utilizing the straight line or "axial flow" design. In operation, the engine works as follows: With the plane standing still, the air from the atmosphere enters the engine at about 300 miles an hour through the inlet duct (1) which is also the engine oil cooler. Expanding through a ring of stationary blades arranged radially inside the engine (2), the air is jumped up to 600 miles per hour before it enters the axial flow compressor (3). The six rows of compressor blades, whirling 18,000 times a minute, pack 50 tons of air an hour into the combustion chamber (4), where it is mixed with fuel and burned. These "combustion products" are expanded by heat to approximately three times the original air volume, and the only manner of escape is through a great increase in speed. Then, in seeking to escape, the gas must first go through another row of stationary blades (5), which directs it into the gas turbine "wheel" (6). From the speeding





(Left) Through this orifice at the "stern" of the engine, gas will stream at more than 1200 m.p.h. when the engine is in operation. (Right) "Down the throat" view of the "Yankee" jet engine. The windmill-like disk of blades directs the air blast into the first row of compressor blades behind it. Each two adjacent blades expand air passing between them.

gas the turbine extracts mechanical power which it transmits back through its shaft to drive the compressor and the engine's auxiliaries (8). A single row of turbine blades made of a special alloy to resist a combination of 1500 degrees heat and the enormous centrifugal forces set up by its high speed produces as much as 3,400 horsepower to drive the compressor. The energy left in the hot gases after they leave the turbine at 600 miles-an-hour is utilized as jet power exhausted through the "nozzle" at the rear (7). To attempt its 1400-pound propulsive thrust, the speed of the gas is developed in the 2' between turbine and jet orifice, jumping in one/seven-hundredths of a second from 600 to more than 1200 miles-an-hour.

Regulation of Germany's Industry

THE NATIONAL ENGINEERS COMMITTEE has announced a plan for postwar control of Germany's war potential through strict regulation of German industry. This represents a year's study by 35 engineers and technological specialists, undertaken at the invitation of the State Department.

The report asserts that danger of German rearmament can be overcome by control of power production and distribution and of industrial plant construction, to prohibit the synthetic fixation of nitrogen, prohibit production of synthetic liquid fuels, prohibit development or use of atomic energy, limit capacities and production of steel and steel products plants, and prohibit production of aluminum.

Gas Range Design Contest Announced

OF SPECIAL INTEREST TO DESIGNERS, architects and engineers is the $18,000 Magic Chef design competition for the "Gas Range of Tomorrow" recently announced by the American Stove Company, and sponsored by the Architectural Forum.

The contest imposes few limitations on the designs. In addition to the over-all design and appearance, there is also the problem of new features to be incorporated in the range, which makes the job of cooking more convenient. Designers should also bear in mind that their suggested models must be practical for volume production.

Designs may show a radical departure from existing practice, or they may involve only slight modifications. If desired, a series of designs may be submitted, ranging from slight modification of current models to a type completely different in construction, appearance, and arrangement.

The cash awards are as follows: 1st prize, $5,000; 2nd prize, $3,000; 3rd prize, $2,000; three prizes of $1,000 each; and 10 prizes of $500 each. The contest opened in November and closes March 1, 1946. The rules booklet, which also incorporates the basic technical data required in initiating a design, may be obtained free of charge by writing to George Nelson, American Institute of Architects, c/o The Architectural Forum, Department P-4, Empire State Building, 350 Fifth Avenue, N. Y., mentioning the Magic Chef design contest.

RECENTLY ELECTED SOCIETY OFFICERS

American Standards Association, 70 E. 45th St., New York 17. President—Henry B. Bryans, Philadelphia Electric Co.; Vice President—Frederick R. Lack, Radio Division, Western Electric Co.; Chairman of Standards Council—E. C. Crittenden, National Bureau of Standards; Vice Chairman of Standards Council—L. F. Adams, General Electric Co.

Porcelain Enamel Institute, 1010 Vermont Ave., N. W., Washington 5, D. C. President—R. H. Turk, Pemco Corp.; Treasurer—William Hogenson, Chicago Vitreous Enamel Product Co.; Secretary—Edward Mackasek.

Aircraft Industries Association, Shoreham Building, Washington 5, D. C. President—Lamotte T. Cohn, Northrop Aircraft; Vice Presidents—Robert E. Gross, Lockheed Aircraft Corp. and Lawrence D. Bell, Bell Aircraft Corp.; Chairman of Board of Governors—Eugene E. Wilson, United Aircraft Corp.; Secretary-Treasurer, Harrison Brand.

National Association of Manufacturers, 14 W. 49th St., New York. President—Robert R. Wason, of Manning, Maxwell & Moore; Chairman of the Board—Ira Mosher, Russell Harrington Cutlery Co.; Executive Vice President—Walter B. Weisenburger.

National Machine Tool Builders Association, 10525 Carnegie Ave., Cleveland, Ohio. President—William P. Kirk, Pratt & Whitney; First Vice President—Herbert H. Pease, New Britain Machine Co.; Second Vice President—A. G. Bryant, Cleereman Machine Co.; Treasurer—Richard E. LeBlond, LeBlond Machine Tool Co.

United Engineering Trustees, 29 W. 39th St., New York 18. President—J. P. H. Perry, Turner Construction Co.; Vice President—Everett S. Lee, General Electric Laboratories; Secretary—John H. R. Arms.

American Welding Society, 29 W. 39th St., New York 18. President—Wendell F. Hess, Rensselaer Polytechnic Institute; First Vice President—Harold O. Hill, Bethlehem Steel Co.; Second Vice President—George N. Sieger, S-M-S Corp.

MEETINGS

American Society for Metals—Metals Exposition, Feb. 4-8, Cleveland Public Hall, Cleveland, Ohio.

American Society of Heating and Ventilating Engineers—Annual meeting, Jan. 28-30, Hotel Commodore, New York.

Society of the Plastics Industry—Low Pressue Conference, Feb. 1-2, Edgewater Beach Hotel, Chicago.

Institute of the Aeronautical Sciences—Annual meeting, Jan. 29-31, Columbia Univ., New York.

Supersonic Waves Detect Flaws in Metal

ULTRA-HIGH SOUND WAVES now make it possible to "see" flaws inside metals, to "look" through great depths of water and detect submarines, or even homogenize and sterilize milk, Dr. Roman Smoluchowski, General Electric scientist, said in an address recently delivered at the University of North Carolina. "The magnitude of supersonic vibrations obtained and measured in laboratories," according to Dr. Smoluchowski, "can vary anywhere from displacements hundreds of thousands of times smaller than atoms to displacements which can break metals." The acceleration produced has unusual effects. It can be two million times greater than that of a falling object. The waves also accelerate chemical reactions to make better television reception by scanning the picture before it is presented on the viewing screen, to improve photographic emulsions, and to clear smoke out of the air by precipitation.

Plastics Engineers Present Varied Program

THE NATIONAL PROFESSIONAL ACTIVITIES COMMITTEE of the Society of Plastics Engineers has prepared an interesting program of technical sessions for its annual meeting, Jan. 7-11, in Detroit. The first day's program is divided into two sessions: Materials and Molding Technique. A novel talk by Mr. W. Goggin of the Dow Chemical Co. on "German Plastic Fabrication Methods" will highlight the latter session.

A Laminates Symposium will occupy the entire second day of the S.P.E. meeting. Of special interest are the following papers: "Semi-Structural Fabrications" by Mr. C. F. Marschner of the Forest Products Lab.; "Engineering Properties of Fiberglas Reinforced Plastics" by Mr. G. Slayter of Owens-Corning Fiberglas and "Low Pressure Molding Materials and Technique" by J. Walter Noble of Fabrican Products.

On the third and last day of technical discussions, four sessions devoted to as many topics are scheduled: Tool Design, Coatings, Consumer Specifications and Product Design. In the last two sessions, talks of wide interest are "Stability of Phenol Formaldehyde Plastics by Mr. F. A. Martin of the Hoover Co. and "What Design Engineers expect of the P.A.C." by John Sasso, Managing Ed. of PRODUCT ENGINEERING.

NACA Industry Committee Elects Officers

J. H. KINDELBERGER, President of North American Aviation, Inc. was elected Chairman, and H. M. Horner, President of United Aircraft Corporation was elected Vice Chairman of the NACA's Industry Consulting Committee at the group's first meeting at Cleveland, Ohio. T. L. K. Smull

was appointed Engineering Secretary.

The Industry Consulting Committee, consisting of eight aviation industry heads, was formed recently to advise the NACA as to general research policy and programs, especially with regard to the needs of industry. The other six members are Lawrence D. Bell, President, Bell Aircraft; Jack Frye, President, TWA; Robert E. Gross, Lockheed Aircraft; Beverly Howard, Hawthorne School of Aeronautics; C. Bedell Monro, PCA; William T. Piper, Piper Aircraft.

At the Cleveland meeting the Industry Consulting Committee met and exchanged ideas with members of the NACA involving research programs and consulting procedures.

DISCUSSIONS AND COMMENTS FROM READERS

Educational Improvement Editorial Draws Praise

To the Editor:

Congratulations on your fine editorial in the July issue of PRODUCT ENGINEERING. It is a source of satisfaction to see such a subject as technical education treated so importantly in a nonacademic journal of high standing.

You will be interested to know that we are about to expand our research education program through a series of fellowships and other grants. Through this plan the student, after finishing his courses at a technical school, can come to us for six months or a year for an "interneship" as a research worker. During this time he will work on a problem of fundamental importance to industry. When we have the plan completely worked out, details will be made available to all who are interested. —J. R. VAN PELT

Battelle Memorial Institute

To the Editor:

Allow me to express my appreciation for the editorial on improving technical education in your July issue. This is the neatest statement of the facts and the best reasoned argument on the subject I have seen. I hope this editorial will be followed by others on this subject, and also by articles expanding on the thesis presented. Although educators saw our present situation coming, apparently they were unable to cope with the problem. Unfortunately even employers of technical personnel see no reason to be overly concerned. It is not difficult to see why the general public barely suspects that such a problem exists. —ANDREW DOUGLAS

Monsanta Chemical Co.

EDITOR'S NOTE: Forthcoming issues of PRODUCT ENGINEERING will contain articles discussing additional phases of technical education.

Further Comment on Designers' Society Editorial

To the Editor:

In reference to your editorial on the American Society of Design Engineers, I am of the opinion that the multiplicity of associations and societies has reached a point where there is no further room for new societies. However, if a section of the A.S.M.E. is formed for the design engineers, it is my opinion that this will be the better way to handle the matter.

It might be well to state here that there may be considerable question in the minds of engineers as to what constitutes a design engineer and what branch of the A.S.M.E. the individual would be included under in addition to the question of design. It would seem that the design engineer might be engaged in the designing of anything from a coffee pot to a large structural building and in all probability, such design engineers would have very little in common. If the question is based upon design engineers of the type that is streamlining practically everything, possibly these men would have considerable in common but there would probably not be enough to form a separate division of the A.S.M.E. —S.A.G.

To the Editor:

I read your October editorial, "The American Society of Design Engineers" with a great deal of interest.

Unquestionably, industry could be better served than at present if those engineers primarily interested in design were provided with a suitable meeting and clearing house for interchange of information and ideas. I believe that a logical way to accomplish this would be to set up a machine design division of the American Society of Mechanical Engineers. If this were done, the prestige and facilities of a well entrenched national engineering organization would be available to the new group. The activities of the design division would supplement and bolster those of the other divisions comprising the Society and its helpfulness would be limited only by the willingness of the other divisions to furnish design material for technical sessions and to utilize its services whenever possible.

Also, the new organization would not be initially handicapped by having to function without the resources, facilities or personnel required to suitably advertise itself and to do an adequate job in such an extensive and important field.—DANIEL VAUGHN WATERS

To the Editor:

My attention has just been called to the editorial in the October issue and the various comments in the November issue on the American Society of Design Engineers. I believe that such a society would be very beneficial to the design engineer and that it will undoubtedly come about.

As a past member of the A.S.M.E. I am very skeptical of the advantages of organizing as a section of that society. I think that a more aggressive society would result if it were organized as an independent body. I am not a member of the American Society of Tool Engineers but my observations thus far lead me to believe that they have accomplished far more as an independent society than as a section of any other large society. Most of my colleagues appear to have about the same views on this subject. —H. BROOK

Saco-Lowell Shops

Urges Adoption of Uniform Sheet Stock Standards

To the Editor:

I should like to know if PRODUCT ENGINEERING readers are in favor of the adoption on a national scale of a single standard of thicknesses for sheet stock of all materials, using the ASA Standard, B32.1-1941, or one of equal value. I have addressed the National Bureau of Standards, The American Standards Association, the American Iron and Steel Institute, The American Warehouse Association, and have talked to a number of industrial leaders, and in each case the adoption of such a standard in American practice by all industry was highly favored from several standpoints; invariably the reply is that the job must be done by all industries together or all concerned with one industry such as steel, because of the mutual dependence of one group on another.

The ASA feels that the move is up to industry, the warehouse association can do nothing until the designers specify such a standard, the steel mills have the same answer, and the designers in any industry can not adopt such a standard until they can be assured of reasonable supply. For this reason I proposed to the above mentioned organizations that a national survey be conducted with the idea of determining the wishes of the various industries, and if favorable, providing for a period of possibly eighteen months for the changeover. The ASA Standard B32.1-1941, is a very simple one containing certain natural nommals expressed in decimals of an inch and the matter of adjusting the commercial tolerances is not too great a handicap. I think that at the same time the whole subject of commercial tolerances in each metals industry might well be over-hauled.

The change-over has the support of Northrop Aircraft, and I believe of the aircraft industry which is only a small part of general industry; but this move must begin somewhere and your support will be greatly appreciated.

I intend to request that the Aircraft Industries Association make the request to the American Standards Association, that a national survey be conducted in the near future in order to secure, if possible, the actual national use of this standard.

—G. M. ARON

Standards Engineer

NEW MATERIALS AND PARTS

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Bimetallic Dial Thermometer

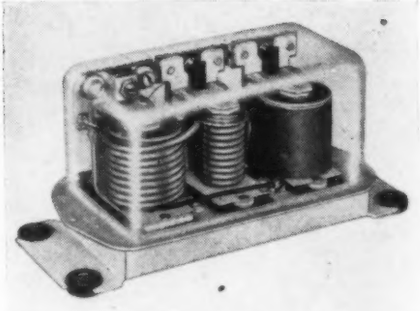
Equipoise Controls, 342 Madison Ave., New York 17, N. Y.

This thermometer is claimed to have a permanently-calibrated, accurate, and responsive bimetallic helical coil measuring element. Expansion of bimetallic coil rotates the attached small shaft and indicating pointer as one unit over entire scale range. There are no pivots, mechanical linkages or gears. An unbreakable glass crystal can be furnished. Various standard ranges are available between limits of —90 deg. F. and 1,000 deg. F. Test or laboratory thermometers are graduated in both C. and F. on same scale. Temperature can be increased 50 percent or more beyond end of scale range without damage to thermometer for ranges up to 500 deg. F., and 10 percent over-range for ranges up to 1,000 deg. F. Thermometers are obtainable in 2, 3, and 6 in. dial sizes. Installed by connecting ½ in. standard connection nut directly into the point of service or into separable socket or other type of mounting accessory. Separable sockets are high-pressure type designed for universal service conditions, having 1 in. or ¾ in. standard connections.

Voltage Regulators

R-B-M Mfg. Co., Logansport, Ind.

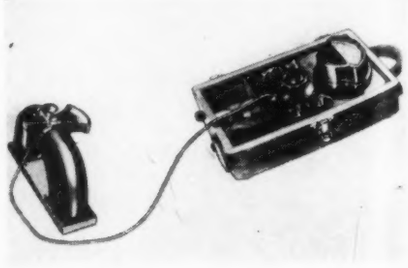
These regulators are suitable for stationary or mobile gas engine or motor driven generators. All three units (reverse current relay, voltage control, and current limiter) are designed to work in any position and withstand external vibration and shock normally encountered in mobile apparatus. The complete assembly is sealed in a gasketed, drawn steel inclosure. They are available in maximum capacities of 30 amp. at 6 to 32 volts and 45 amp. at 6 to 12 volts d.c. Maximum field current rating—3 amp. at 6 volts; 0.5 amp. at 32 volts d.c. Approximate dimensions—width, 7¾ in.; depth, 4 in.; height, 3½ in. Average weight, 3.25 lb. Because these regulators must be calibrated as to settings and resistance values to match generator specifications, it is necessary to consult the manufacturer's engineering department, giving complete characteristics of generators, in order to obtain detailed information regarding definite applications.



Fluxmeter

Marion Electrical Instrument Co., Manchester, N. H.

This direct-reading fluxmeter can be used to measure magnetic fields and gaps ½ in. or greater, within the range of 1200 to 9600 gauss. The fluxmeter consists of two D'arsonval instruments connected in series and suitable shunts, current and range selection controls. The probe meter derives its energy from the magnet under test. A current of sufficient magnitude is passed through its moving coil assembly to deflect it to a fixed or set point on its scale. This current is then measured in terms of gauss on a suppressed scale milliammeter. Data on the unit is as follows: Weight 6½ lbs. Car-

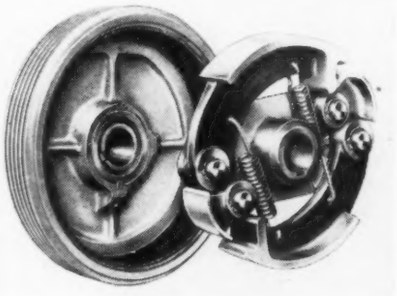


rying case measures 5 in. x 6 in. x 10½ in. Power source—one Type D flashlight cell. The cable on the probe element is 4½ ft. long. The unit is provided with adapters for use with magnetron magnet assemblies having gaps of 0.550 in. to 0.750 in. with pole diameters of ¾ in. and with adapters for gaps of 1.3 to 1.5 in. with pole faces of 1⅝ in. and 2 in. in diameter. For magnetic measurements in fields of non-standard magnets, and other sources, the probe element is marked with centering lines and provided with a handle so that it may be inserted into any field.

Automatic Clutch

Salsbury Motors, Inc., 4464 District Boulevard, Los Angeles 11, Calif.

This unit, installed directly on the shaft of any engine or electric motor, progressively applies the power to the driven machine. It engages and disengages automatically. This mechanical clutch permits disengagement while idling and engagement when driving, with no slippage. The clutch is an opposed shoe type, dual-spring balanced. Below a predetermined r.p.m. of an engine or motor, the clutch idles; when the driving r.p.m. increases beyond the stipulated r.p.m.



the expansion shoes press outwardly, contacting the friction lining of the drum. Two models are available, one for the range from fractional to 3 hp., and one for up to 6 hp. Different drives can be mounted on the shaft, V-belt or flat-belt pulley, gear, sprocket, coupling, or a variable speed transmission. The 3 hp. model has a drum diameter of 5¼ in. and length of 2⅛ in.; the 6 hp. model has a drum diameter of 7¼ in. and length of 4½ inches.

Explosive Rivet

E. I. du Pont de Nemours & Company, Wilmington, Del.

Retaining basic features of previous types, this design eliminates the necessity for close tolerance drilling and provides rivets which will accommodate a wide range of metal thicknesses. After explosive rivets are in place, the tip of an electrically heated iron is applied to the rivet heads. Heat fires the explosive charge within approximately two seconds. The shank of the rivet is expanded to fill the hole completely and a barrel-shaped head is formed on the "blind" end to lock the rivet in place. The strength of these rivets is less than that of conventional solid rivets. These rivets are available in ⅛ in., $\frac{5}{32}$ in. and $\frac{3}{16}$ in. diameters and are made of various materials including several aluminum alloys, brass, copper, mild steel and Monel metal.

Video Amplifier

United Cinephone Corp., Torrington, Conn.

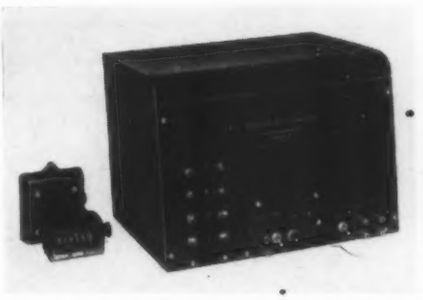
This amplifier has been designed primarily for use in amplifying complex waves to be viewed on an oscilloscope. It is also useful in laboratory work as an audio amplifier, and for tracing and measuring small R. F. voltages. The frequency response is flat with-

in 1.5 db. of the 10 kc. response for 15 cycles to 4 megacycles. The phase shift is reduced to provide reproduction of pulses of one microsecond, and square waves at repetition rates as low as 100 a second. The gain is approximately 1000 when direct input is used. Input is normally through a probe, furnished with the equipment, having an attenuation of 10 times. The amplifier direct input (without probe) is approximately 2.2 megohms of resistance in parallel with 40 mfd. This compares with 1.1 megohm resistance in parallel with approximately 18 mmfd. when the probe is used. The output voltage can be adjusted from zero to 50 volts r.m.s. with sine wave signals. The ripple output is less than 0.5 volt for all operating conditions and all positions of gain control. The Video Amplifier operates on a voltage of 110-120 volts, 60 cycles with a power consumption of 100 watts. It weighs 35 lb. complete with tubes and probe, and occupies a space of 7¾ in. by 9 in. by 20¾ inches.

Electronic Counter

Potter Instrument Co., 136-56 Roosevelt Ave., Flushing, N. Y.

This counter unit is applicable for counts exceeding 10 cycles per sec. and in installations where mechanical counters wear out prematurely because of the high-speed continuous operation. Used alone as a two-decade instrument, the maximum count capacity of the electronic counter is 100. A tube-operated relay is provided for cases

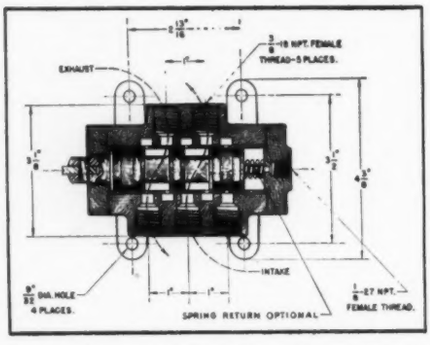


where the quantity to be counted exceeds 100. The relay has a single-pole, double-throw contact which is brought out to terminals on the front panel of the unit, and operates once for each 100 counts. An electro-mechanical counter may be connected in series with these terminals and an appropriate external power source, such as the a.c. line. Each 100 counts of the electronic counter will then cause one operation of the electro-mechanical counter. When operation of the relay and an external mechanical counter are not involved in the application of the two-decade electronic counter, it may be used alone, at counting rates up to 20,000 per sec. The instrument comprises an input section, suitable for any of the four enumerated types of input circuits: contact closure, pulse signals, sine-wave signals, and square-wave signals. It further consists of two standard counter-decades, designated respectively as the "units decade" and the "tens decade," an output relay stage, and a power supply. The two-decade electronic counter is complete with power supply, and is ready for operation from a nominal 115 volts, 60 cycle, a.c. power line. No special types nor special selection of vacuum tubes are required for the counter's 12-tube complement. The cased instrument measures 13½ in. wide, 8⅝ in. high, 10 in. deep, and weighs 26 pounds.

Control Valve

Modern Products, Ltd., 932 So. Grand Ave., Los Angeles 15, Calif.

A 4-way control valve, known as the Model CV Series, has been designed for the control of air and low pressure hydraulic systems. These valves are adapated to hand, foot, or pilot operation by assembly changes of identical housings. The design of the valve permits its use normally "on" or "off" in three positions, with the center position being "neutral." In the "neutral" position, when the valve is used for cylinder control, the unit may be arranged to permit positioning of the piston with pressure balanced on both sides of the piston, or with pressure relieved at both piston ends. All of the adaptations can be used as single 3-way valve by plugging one outlet port or as two 3-way valves in series. When the unit is installed as the two 3-way valves in series, one valve will have the pressure on, while the other will have the pressure off. Using the same assembly of housing, piston rod and end plates, a hand operated CV valve converts to foot operation by removing two clevis pins and replacing the hand



lever with a foot treadle. Conversion of hand or foot operated to pilot operated involves the removal of one end plate and replacement of the piston and end plate. Changes may be made without breaking the line connections. The valve is normally furnished with $\frac{3}{8}$-18 NPT female ports at 1 in. spacing on centers. The valve is also available in $\frac{3}{4}$ in.-18 port size. Mounting pads are $4\frac{3}{8}$ in. overall with $\frac{9}{32}$ in. diameter holes on $2\frac{1}{16}$ in. centers. Width of the valve body, port facing to port facing is $3\frac{1}{8}$ in. Overall width of the valve body is $2\frac{7}{16}$ in. Addition of the handle increases the overall height to the maximum point in the handle arc to $6\frac{3}{4}$ in. by an overall length of $7\frac{5}{16}$ in. Use of the foot treadle increases the length to $10\frac{1}{8}$ in. by $4\frac{11}{13}$ in. to the maximum height reached by the foot treadle.

Battery Charging Indicator

Hickok Electrical Instrument Co., 10544 Dupont Ave., Cleveland 8, Ohio

This instrument, known as the Chargicator, indicates electrically the equivalent gravity of any lead-acid storage battery, regardless of size or voltage. It places no load on the battery and at the time of reading, the battery need not be disturbed. It shows what charging rate to use, either for trickle charging or for a high-rate charge. It indicates the percentage of charge and charging danger and warns of overcharging. Weak or defective cells are spotted before failure occurs and it may also be used as a check against future failure by using it in conjunction with a load test.

Pipe Caps

Tubing Seal-Cap Inc., 215 W. 7th St., Los Angeles, Calif.

These protective and sealing caps and plugs have stamped threads on the body of the plug. It is claimed such threads are produced to gage tolerances (Class 3-fit) without secondary threading operations. Available

from stock are caps and plugs, with NPT threads, in sizes to 1 in., either steel or aluminum. Larger sizes, in metal thicknesses to 0.04 in., can be made to specification.

Cloth-coating Compound

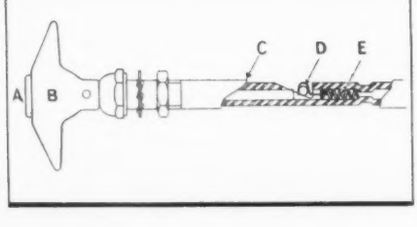
Monsanto Chemical Co., St. Louis, Mo.

A compound of vinyl butyral that retains flexibility at low temperatures. Monsanto claims vinyl butyral compound DB218 has been tested under Quartermaster Corps specifications and found to combine the advantages of vinyl materials with full flexibility, comparable to rubber at 0 deg. F. and colder.

Tension Lock Control

Arens Controls, Inc., 2253 So. Halsted St., Chicago, Ill.

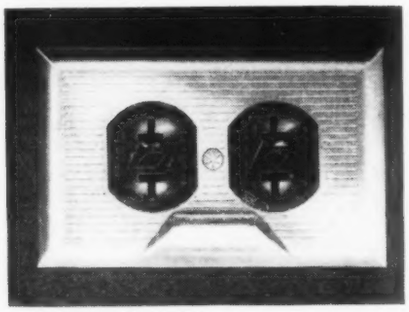
All operating mechanism is contained in the steel sleeve. The sleeve is of $\frac{1}{2}$ in. diameter. Pulling out the control head (B) sets this control to any desired position. Wedge pin (D) locks the control by wedging itself against wall (C) preventing sliding member from moving back. Button (A) depresses spring (E) giving wedge pin clearance of wall and permitting sliding control member to be moved in. Release of button (A) relieves compression on spring (E) which locks pin against wall of control preventing further movement of sliding member. This unit weighs 8 ounces.



Illuminated Outlet Plate

Associated Projects Co., 80 E. Long St., Columbus 15, Ohio.

This plate is molded in a single plastic piece forming an integral housing for the light mechanism. A portion of this housing is fabricated so that the bulb will emit a glow.



LumiNite outlet plates fit standard duplex outlets and are installed by connecting the two lead wires to the terminals on the outlet.

Lifting Clamp

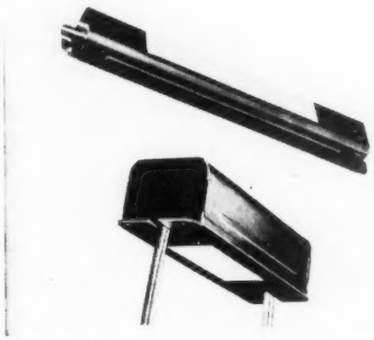
Merrill Brothers, 4618 Arnold Ave., Maspeth, N. Y.

This unit will lift light or heavy plates, barrels or other containers, stampings or welded assemblies, or any metal with sufficient flat surface to enable the jaws of the clamp to engage same. It picks up and holds, irrespective of position of the clamp when attached and lifted, and releases instantly and automatically when the load or weight is relieved from the grip of the jaws. This clamp has two definite clamping principles, one a pressure-grip, the other a wedge grip. The basic cantilever principle actuates the one jaw, the stationary jaw allows the wedge power grip. These clamps are made in four sizes, $\frac{1}{2}$, 1, 3 and 6 ton capacities, and will take from 0 to 2 in. in thickness.

Lamp Ballasts

General Electric, Specialty Transformer Div., Fort Wayne, Ind.

Two types are available. One is a single-lamp type, designed for the operation of 13-watt Mazda F lamps. The other, available in either single-lamp or Tulamp models, is for the instant-starting operation of the Slimline Mazda F lamps. The single-lamp type for the 13-watt lamps has been designed for use on 118-volt, 60-cycle circuits and is equipped with a step-up autotransformer providing the necessary 200 volts to facilitate lamp starting. It is avail-



able in either uncorrected or high-power-factor ratings. The single-lamp and Tulamp styles for the Slimline lamps can be obtained for operation at 100 or 200 milliamperes. They are of the high-voltage type and do not require separate starting equipment. The single-lamp type is available in both uncorrected and high-power-factor ratings, while the Tulamp style is of high-power-factor design. Both styles are housed in two-way-lead cases allowing the leads to be brought out either the end or the bottom.

Ducting Material

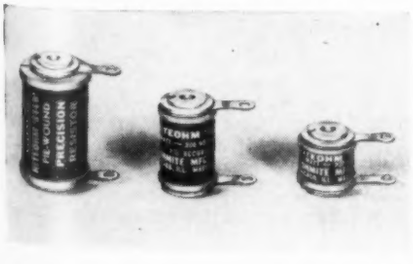
Arrowhead Rubber Co., 2244 E. 37 St., Los Angeles 11, Calif.

A material "Airtron" is made of glass cloth and rubber, and provides very high insulation qualities as well as great flexibility. It withstands temperatures from minus 60 deg. F. to 300 deg. F. with no change in properties and will stand over 50 lb. per sq. in. internal pressure at all temperatures. It is unaffected by air, light, water, gasoline, oil and all but concentrated mineral acids. Manufactured in tubes from 1 in. to 6 in. in diameter and in any length desired, as well as in specialized shapes where required for unusual installations, the ducting can be adapted to any equipment as a replacement or as an original installation.

Resistors

Ohmite Mfg. Co., 4835 Flournoy St., Chicago 44, Ill.

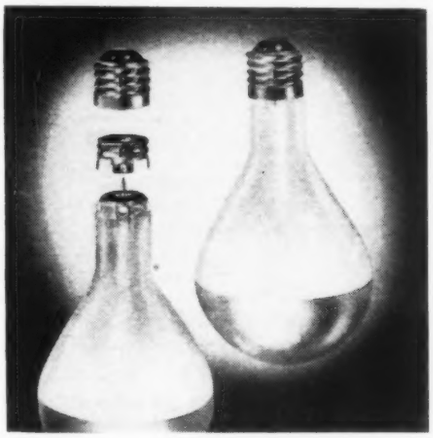
The Riteohm "Series 84" resistor is pie-wound to 1 percent accuracy and is available in 3 sizes, $\frac{9}{16}$ in. diameter by $\frac{9}{16}$ in. long, $\frac{7}{16}$ in. diameter by $\frac{7}{8}$ in. long, and $\frac{3}{4}$ in. diameter by $1\frac{7}{16}$ in. long. The smallest is a 2 pie while the other two are 4 pie units. The minimum resistance is 1.0 ohm for the 2 pie unit and small 4 pie unit, and .10 ohm for the large 4 pie unit. The maximum resistance is 200,000 ohms for the 2 pie, 400,000 ohms for the small 4 pie, and 1.5 megohms for the large 4 pie unit. Common uses for such a resistor are voltmeter multipliers, laboratory equipment, radio and electrical test sets, attenuation pads and in electronic equipment requiring accurate resistance components. Enameled alloy resistance wire is non-inductively pie-wound on a non-hygroscopic ceramic bobbin which has a hole through the center for a No. 6 screw. Lug type terminals on the Riteohm 84 are firmly fastened to the bobbin. After being wound, the unit is vacuum impregnated with a varnish which provides additional insulation and protects the winding against humidity. The resistor can be supplied with a varnish coating containing a fungicidal agent, thus making the unit suited for use in the tropics.



Lamp Base Construction

Appliance Corp., 345 Carroll St., Brooklyn 31, N. Y.

This construction locks bulb to base, and eliminates base cementing and neck strapping. It consists of a threaded collar screwed into and notch-locked to the base, with its collar claws gripping the dimpled neck of the glass bulb. This results in a lock that



cannot be separated by the weight of the bulb, position of burning, heat or age. All standard-line Wabash-Birdseye lamps from 300 watts and upward, and all reflector lamps and industrial infra-red heat lamps will be manufactured with this base.

Triode

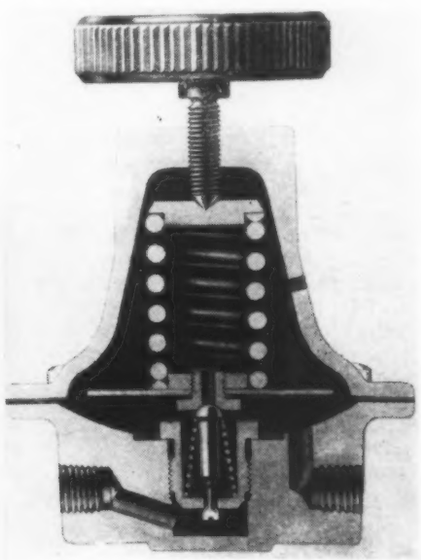
Taylor Tubes, Inc., 2312 Wabansia Ave., Chicago, Ill.

A transmitting (or receiving) triode for the ultra-high frequency field of electronics will operate at full ratings up to 250 mc. and at reduced ratings for higher frequencies. Tube characteristics are: Size, $3\frac{3}{4}$ in. overall height by $1\frac{1}{2}$ in. maximum diameter; Micalex octal base, with grid and plate connections brought out through the top of the tube; Grid to plate capacitance, 3.6 mmfd; Grid to filament capacitance, 1.8 mmfd; Plate to filament capacitance, .095 mmfd; Amplification factor, 10; Filament 6.3 volts a.c. or d.c. at 2.75 amps; Maximum plate power, 750 volts at .075 amps; Plate dissipation, 20 watts. Typical operation: Plate volts, 750; Plate current, 75 milli-amperes; Grid voltage, minus 150 volts; Maximum d.c. grid current, 20 milliamperes; Approximate driving power, 1.5 to 2.5 watts; Approximate carrier output, 40 watts (at 115 m.c.).

Regulator

Conoflow Corp., Philadelphia, Pa.

This unit is designed primarily for manual loading service in conjunction with pneumatic industrial instruments. On deadend service, the regulator can be adjusted to hold air pressure from 0 to 25 lb. constant within 0.05 of 1 lb., regardless of vibration or upstream pressure variation. A nylon-inserted neoprene diaphragm and the floating design of plug and seat contribute to the sensitivity and stability of this unit. Compact and close-coupled, it is suited for mounting in-

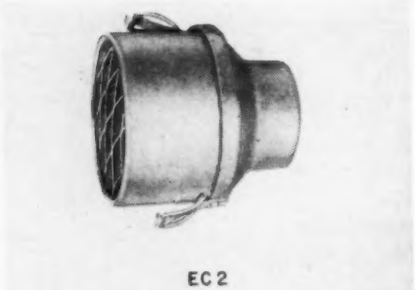


side an instrument case or on a separately mounted panel. Body and spring housing are of forged brass. Plug and seats are highly polished stainless steel, all other steel parts are cadmium plated. Regulator is furnished with large diameter knurled plastic knob and fine thread screw requiring six or more turns for full range adjustment. Threaded spring housing and two lock nuts permit flush mounting or any thickness of panel up to 1 in. Body tappings can be had in either $\frac{1}{4}$ in. or $\frac{1}{8}$ in. standard pipe threads. Finish is dull black enamel. Size, 3 in. diameter $4\frac{1}{4}$ in. overall height.

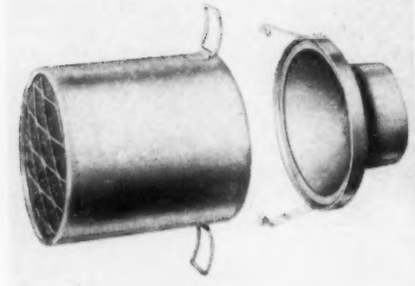
Air Filter

Farr Company, Los Angeles, Calif.

Identified as the Far-Air EC filter, it will be available in diameters of 7 in. to 14 in. with capacities from 90 cfm to 730 cfm. Now ready for shipment are two 7 in. types. The complete unit is composed of the filter element enclosed in a cylindrical steel housing, and a cast iron adapter base. The filter element is of a herringbone crimped screen



EC2



EC4

design. It is spirally wound into a 2 in. pack. For average service conditions, the EC2 filter contains two of these packs. The EC4 filter, containing four packs, is recommended for heavy-duty service. The filters are installed by screwing the cast iron adapter fitting onto the intake pipe. This adapter has a standard 3 in. pipe thread and remains permanently in place. The filter unit is then locked into the adapter, bale handles on the filter unit barrel snapping into heavy-duty spring clips attached to the cast iron adapter. The filter units can be cleaned with high pressure hot or cold water, or by agitating in a tank of any good commercial cleaning solvent. Once cleaned, they should be dried and re-oiled before reinstalling.

Aircraft Lacquer

Monsanto Chemical Co., St. Louis, Mo.

This finish, Skylac, has been developed for use on fabric-covered, exterior control and plane surfaces and on interior decorative areas. It combines weather resistance and tautening effect with fire resistance. Because of its high solids, few coats are required. Skylac is designed to spray at room temperature, and serves not only as an impervious finish but adds structural strength as the covering tightens around the airframe.

Tank De-Icers

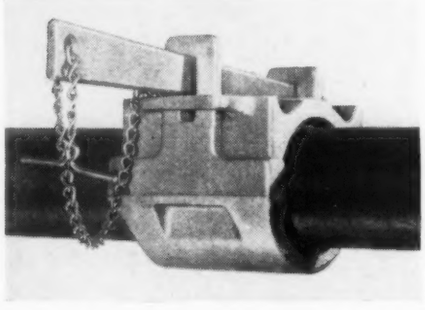
General Electric Co., Schenectady 5, N. Y.

This unit plugs into any 110 to 120 volt, a.c. circuit, and operates at the power rating of 300 watts at temperatures below zero. It will operate in tanks of any size without barriers or insulation. The de-icer consists of a hollow, 20-gage, nickel-plated copper float, a thermostatically-controlled Calrod heating element, and a 15-ft. rubber-covered water and weather-resistant lead. The float is approximately 2½ in. in depth and 10¾ in. in diameter, including the heating element which encircles it. Corners of the float are rounded and sharp edges removed. The thermostat, sealed within the float, regulates the use of electric current and cuts off the power when not needed. The lead is connected to the thermostat and firmly anchored in the bottom of the float through a copper tube which is sealed to the bottom of the disk.

Flexible Pipe Couplings

Drinkwater, Inc., 2323 South Michigan Ave., Chicago, Ill.

Presto-Lock couplings can be used with any plain end pipe without threads, grooves or flanges. No wrenches or special tools are required in assembly. The three parts of this coupling are the two corrosion-resistant malleable iron castings and the locking wedge key. Sizes 1¼ in., 1½ in., 2 in., 2½

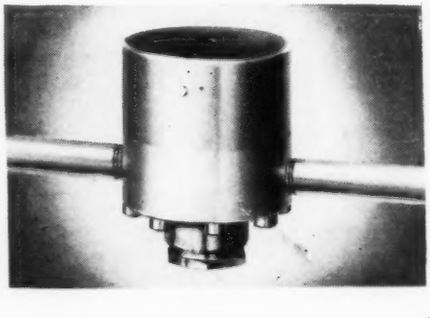


in., and 3 in. are equipped with one wedge key and chain assembly to prevent loss of coupling parts. Sizes 4 to 16 in. have two wedge keys but no chain assembly. The gaskets which are used have been designed to affect a permanently tight seal on all types of pipe lines. Gaskets are available in synthetic rubber, neoprene, and natural rubber.

Pressure Reducing Regulator

Grove Regulator Co., 6501-65 St., Oakland 8, Calif.

This regulator, weighing less than 2 lb. and measuring roughly 2¾ in. x 3¼ in. is suitable for handling initial pressures up to 3,500 lb. per sq. in. with adjustable control range from 5 to 1,500 lb. per sq. in. Special models can be supplied for higher initial pressures up to a maximum of 5,000 lb. per sq. in. Although primarily designed for air and gases, this unit can also be furnished

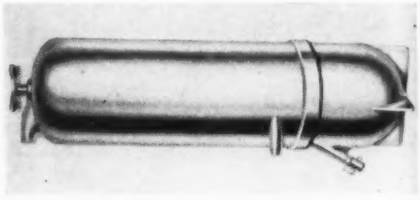


for liquid service. The valve and seat construction was designed for positive dead-end shutoff. It is instantaneous in its operation, and available for ⅛ in. and ¼ in. pipe size.

Grinder Coolant Filter

Cuno Engineering Corp., Meriden, Conn.

The "Coolant-Klean" has a replaceable (bag-type) filter element mounted on a screen spacer to provide a filtering area of 1,000 sq. in. No filter aid is needed. When replacement of the bag is necessary, a single screw clamp opens the filter, the dirty ele-

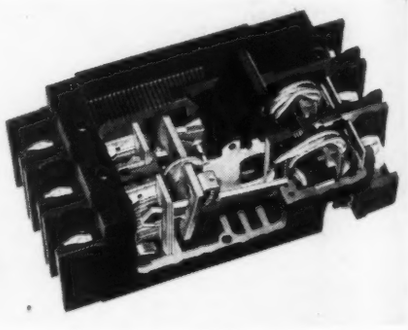


ment is discarded, and the accumulated grit emptied from the sump. The "Coolant-Klean" can be applied to any type of grinder and is adaptable to any machine using a coolant or cutting oil. No alteration of the grinder is necessary.

Circuit Breaker

Square D Co., 6060 Rivard St., Detroit 11, Mich.

These units have a dust resisting sheet steel enclosure with front operated handle. They are available for 3 and 4 wire solid neutral applications in addition to 2 and 3 pole de-



vices. Weatherproof, dust-tight and explosion-resisting inclosures are also available for Class I Group D and Class II Group G hazardous location applications. Ratings are 15 to 100 amp.—600 volts a.c., 50 to 100 amp. 250 volt a.c.-d.c., 2 and 3 pole. These breakers are also furnished for panelboards.

Lubricant

Union Carbide and Carbon Corp., 30 E. 42nd St., New York 17, N. Y.

An internal combustion engine lubricant particularly for cold weather use, has properties different in many respects from oils derived from petroleum. The lubricant can be manufactured to any desired viscosity and

is wax-free. Pour-points vary from —30 to —80 deg. F. Flash points range from 300 deg. F. up. Carbon residue values are less than 0.01 percent, regardless of viscosity. The lubricant is characterized by low change of viscosity with change in temperature, having viscosity indices in the range of 140 to 160. It is claimed this lubricant practically eliminates sludge and varnish formation in the engine.

Circuit Breaker

Heinemann Circuit Breaker Co., 109 Plum St., Trenton, New Jersey.

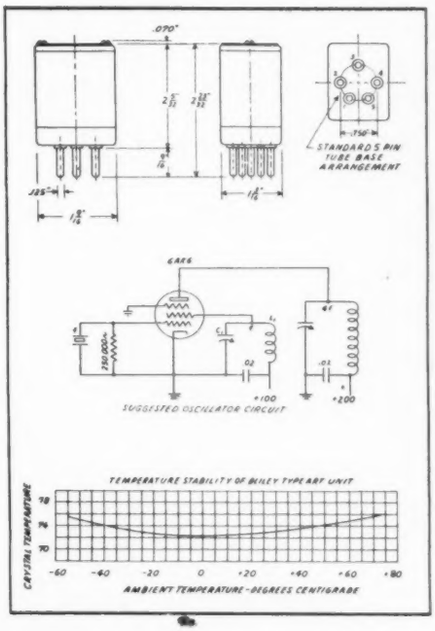
A three-pole breaker with three trip units that act immediately on short circuit or dangerous overload. The circuit breaker has a true inverse time delay in a hermetically

sealed unit which allows passage of harmless current surges. Continued overload, however, opens the breaker in time inverse to the ratio of the current. The three trip units open simultaneously if an overload or short circuit occurs in any one leg. This breaker is designed for service on 120/230 volt a.c. or 250 volt d.c. or 50 amp. maximum. Overall dimensions are 5¼ in. long, 2 11/16 in. high, and 3 in. wide.

Crystal Unit

Bliley Electric Co., Erie, Pa.

This unit, type ART, is a temperature controlled crystal assembly designed for services where frequency stability must be maintained for temperatures ranging from minus 55 deg. C. to plus 75 deg. C. A built-in heater operating on 6.3 volts at 1 ampere provides temperature control within ±2 deg. C. This permits an over-all frequency tolerance of ±0.005 percent or better including variations due to temperature change as well as tolerances required for crystal production. It is available for any

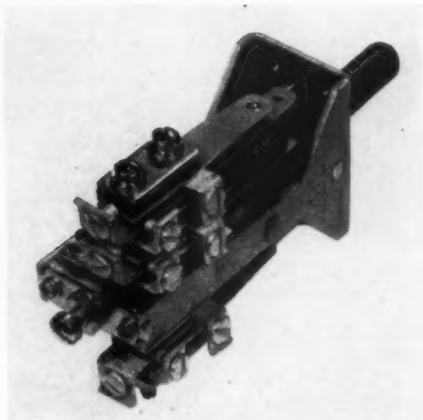


frequency between 3,500 kc. and 11,000 kc. The suggested oscillator design illustrates efficient frequency multiplication.

Terminals

Donald P. Mossman, Inc., 612 N. Michigan Ave., Chicago, Ill.

An optional terminal arrangement for Mossman Series 4100 and 4500 Heavy Duty Lever Switches, and Series 6300 and 061T Heavy Duty Turn Switches. The 41ET and

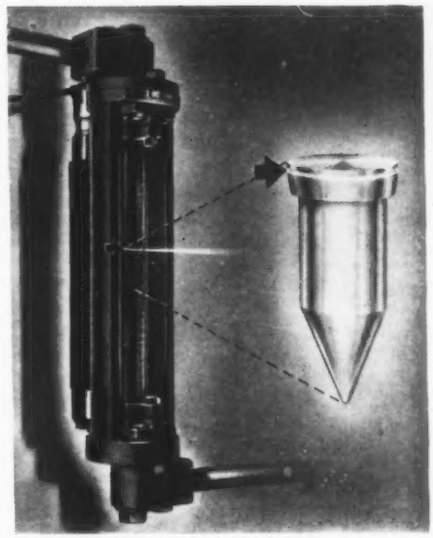


41ETM terminals do not change the operation of switch, the terminals correspond with the spring pileups. Terminals are silver-plated brass with #6-32 binding head machine screws and a #6 plain washer. Up to #10 wire may be used.

Rotameter Rotor

Schutte & Koerting Co., Philadelphia, Pa.

This rotor has a disc of light-transmitting material sandwiched in the rotor head which reduces the distance that the light must travel through the opaque liquid from its

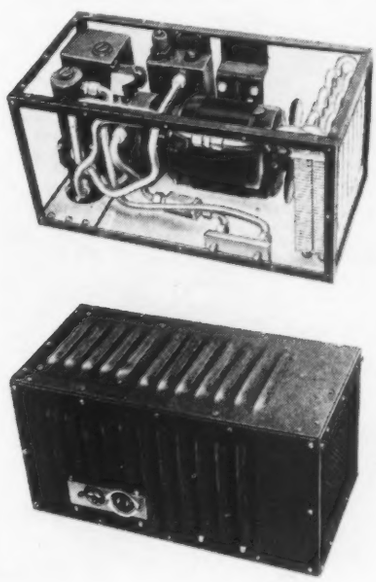


source behind the tube. Rate-of-flow is delineated in the resultant band of light on the tube reference scale. This rotor can be used for practically any application and in any type tapered glass tube rotameter. Two types of discs can be furnished, Lucite for general applications, and Pyrex glass for extremely hot or highly corrosive fluids.

Heat Dissipator

The Eastern Engineering Co., New Haven, Conn.

A unit for commercial heat dissipating applications, furnished with thermostat control, thermostatic valves and flow switch. Unit illustrated will dissipate up to 1,200 watts with a constant controlled temperature, irre-



spective of surrounding temperature, within a heat control range of 2 deg. C. This unit, 16 in. x 7½ in. x 7½ in., is available in steel, bronze, or aluminum. Models can be built to dissipate up to 5,000 watts.

MANUFACTURERS' PUBLICATIONS

NEEDLE BEARINGS—The Torrington Co., Bearings Div., Torrington, Conn. Manual, 153 pages. Edition 32. Engineering and application data on the various types of needle bearings supplied by this firm.

LUBRICATING OIL PRESSURE SYSTEM—Dumametallic Corp., 2104 Factory St., Kalamazoo, Mich. Bulletin, 4 pages. Description, applications, and specifications of the Dura Pressure Units for circulating lubricating oil.

HOSE LINES—Aeroquip Corp., Jackson, Mich. Folder, 5 pages. Description and specifications of hose lines, hose fittings, and hose assemblies.

FREQUENCY METERS—James G. Biddle Co., 1211-13 Arch St., Philadelphia, 7, Pa. Bulletin 1770, 16 pages. Information and data on vibrating-reed frequency meters.

ELECTRIC MOTORS—Electrical Engineering and Mfg. Corp., 4606 W. Jefferson Blvd., Los Angeles, 16, Calif. Booklet, 32 pages. Information on the production facilities of this firm and data on some of the units manufactured.

LIQUID METER VALVES—Morganite Brush Co., Long Island City, 1, N. Y. Folder, 5 pages. Descriptive information on liquid meter valves and slides.

ELECTRICAL CONTACTS—The Stackpole Carbon Co., St. Marys, Pa. Booklet, 36 pages. Information and specifications on all types of electrical contacts.

LUBRICATING SYSTEMS—The Farval Corp., Cleveland, Ohio. Folder, 4 pages. Information on how the Farval system operates and statements of results attained.

BRONZE BUSHINGS—Shook Bronze Corp., Lima, Ohio. Catalog No. 45, 17 pages. Listings of stock sizes of bushings and bars.

MOTOR-GENERATOR REPAIR EQUIPMENT—Ideal Commutator Dresser Co., Sycamore, Ill. Catalog, 36 pages. A complete listing of motor-generator maintenance and repair equipment.

PERMANENT MAGNETS—The Arnold Engineering Co., 147 East Ontario St., Chicago, 11, Ill. Booklet, 22 pages. Information on the design, fabrication, and application of permanent magnets.

PLATE AND SHEET STEEL FABRICATION—Littleford Bros., Inc., 506 E. Pearl St., Cincinnati, 2, Ohio. Booklet, 26 pages. Illustrative information on the types of fabrication produced by this firm.

MANAGEMENT ENGINEERING — Methods Engineering Council, 822 Wood St., Pitsburgh, 21, Pa. Booklet, 20 pages. Information on methods engineering, training, plant layout and design, job evaluation, wage incentive plans, and personnel appraisal.

LUBRICANTS—Merco Nordstrom Valve Co., Pittsburgh, 8, Pa. Booklet No. V-105 Rev. 6, 34 pages. A complete listing of the types of Nordcoseal lubricants required for various industrial applications.

PLASTICS—Durez Plastics & Chemicals, Inc., North Tonawanda, N. Y. Pamphlet, 6 pages. Information and data on phenolic molding materials and the uses of resins.

PLASTICS—The Watertown Mfg. Co., Watertown, Conn. Booklet, 44 pages. Information and data on various types of molding plastics and illustrative information on the molding work of this firm.

GEAR PUMP—Pesco Products Co., 11610 Euclid Ave., Cleveland, 6, Ohio. Bulletin No. 101, 2 pages. Data and specifications on the Pesco high pressure gear pump.

ELECTRIC CONTROLS—United Electric Controls Co., 69-71 A St., Boston, 27, Mass. Booklet, 10 pages. A condensed catalog and price list of the products manufactured by this firm.

HYDRAULIC UNITS—Pesco Products Co., 11610 Euclid Ave., Cleveland, 6, Ohio. Bulletin No. 11, 4 pages. Descriptive information on hydraulic pumps, valves and motors.

CELLULAR RUBBER—Sponge Rubber Products Co., Derby Place, Shelton, Conn. Pamphlet, 4 pages. Describes various forms in which sponge rubber, bonded fiber, and other sub-density materials are manufactured.

HYDRAULIC PUMPING UNITS—Sundstrand Machine Tool Co., Rockford, Ill. Pamphlet, 4 pages. Descriptive information on the operating principles and applications of these units.

CRANK TYPE CYLINDERS—Askania Regulator Co., 1603 S. Michigan Ave., Chicago, 16, Ill. Pamphlet, 4 pages. Data and specifications on crank type cylinders.

AUTOMATIC CONTROLS — Askania Regulator Co., 1603 So. Michigan Ave., Chicago, 16, Ill. Bulletin No. 124, 12 pages. A complete description of the automatic controls furnished by this company to the glass industry.

WIRE CLOTH—Cambridge Wire Cloth Co., Cambridge, Maryland. Bulletin No. 80, 4 pages. Descriptive information on wire cloth and wire cloth products.

ELECTRIC CONNECTORS— Cannon Electric Co., 3209 Humboldt St., Los Angeles, 31, Calif. Catalog, 64 pages. Complete information and data on the Cannon type K and RK plugs and connectors.

FLUID POWER UNITS—Simplex Engineering Co., Zanesville, Ohio. Booklet, 6 pages. Information and specifications on the Seco fixed displacement radial pumps.

MOLDED SYNTHETIC RUBBER — Aero-Seal Rubber Products, 113 North Green St., Chicago, 7, Ill. Booklet, 32 pages. Complete information and specifications on the molding of mechanical parts in synthetic rubber.

THERMOSTAT—United Electric Controls Co., 69-71 A St., Boston, 27, Mass. Bulletin No. 441T, 4 pages. Information and specifications on the Type K thermostat.

ELECTRICAL EQUIPMENT — Cutler-Hammer, Inc., Milwaukee, Wis. Merchandising Catalog, 65 pages. Information on safety switches and service control and a condensed section on motor control and electrical specialties.

TEST MACHINES — Globe Industries, Inc., 125 Sunrise Place, Dayton, 7, Ohio. Bulletin No. V-1, 3 pages. Specifications on vibration and rocker test machines with capacities to 10,000 lb.

ELECTRIC PRESSURE SWITCH — United Electric Controls Co., 69-71 A Street, Boston, 27, Mass. Bulletin No. 451P, 2 pages. Information and specifications on the type ACP-3 electric pressure switch.

ELECTRIC FEEDRAIL—Feedrail Corp., 125 Barclay St., New York 7, N. Y. Pamphlet, 4 pages. Descriptive information on the Feedrail system of enclosed electric rails and trolleys for portable motors, lights, and other moving electrical equipment.

ROTARY SOLENOIDS—George H. Leland, 145 Webster St., Dayton 2, Ohio. Booklet No. 100, 8 pages. Information on the Ledex rotary solenoids and their applications.

ELECTRONIC GAGES—Jack & Heintz, Inc., Cleveland, Ohio. Booklet, 16 pages. Information and specifications on the electronic gages, indicators and comparators manufactured by this firm.

PLASTICS—American Cyanamid Co., 30 Rockefeller Plaza, New York 20, N. Y. The first issue of "Plastics Newsfront," an external house magazine dealing with applications of molding compounds, resin adhesives, and laminating resins.

DUCTING—Arrowhead Rubber Co., 2244 East 37th St., Los Angeles 11, Calif. Pamphlet, 4 pages. Information on "Airtron" ducting and its applications.

CUT-OFF REGISTER CONTROL—General Electric Co., Schenectady, N. Y. Booklet, 8 pages. Descriptive information on cut-off register control for paper fabricating and packaging machines.

Nomogram for Shaft Design

CARL P. NACHOD
Nachod & U. S. Signal Co., Inc.

THE accompanying nomographic chart is designed for solid round shafts loaded both in torsion and in flexure. The chart gives the relations between the four factors.

d = shaft dia., in.
S = resultant shearing stress at outside fiber, lb. per sq. in.
M = bending moment, in. lb.
T = torque moment, in. lb.

The chart has a double range. The outer scales are used for small quantities. The inner scales are used for large quantities.

The following example is solved on the chart (see dash lines).

EXAMPLE: What should the diameter of a shaft be, when

T = 4,000 in. lb.
M = 3,000 in. lb.
S = 18,000 lb. per sq. in.

SOLUTION: Connect the T and M points on the respective scales with a straight line. Next, lay off this line on the T scale. This determines point 5,000 on the T scale. Draw an extended secant from this point through point 18,000 on the S scale to the d scale. The point on the scale cut by the secant is the shaft diameter, which, in this example, is 1⅛ inches.

The nomograph is constructed to solve the equation

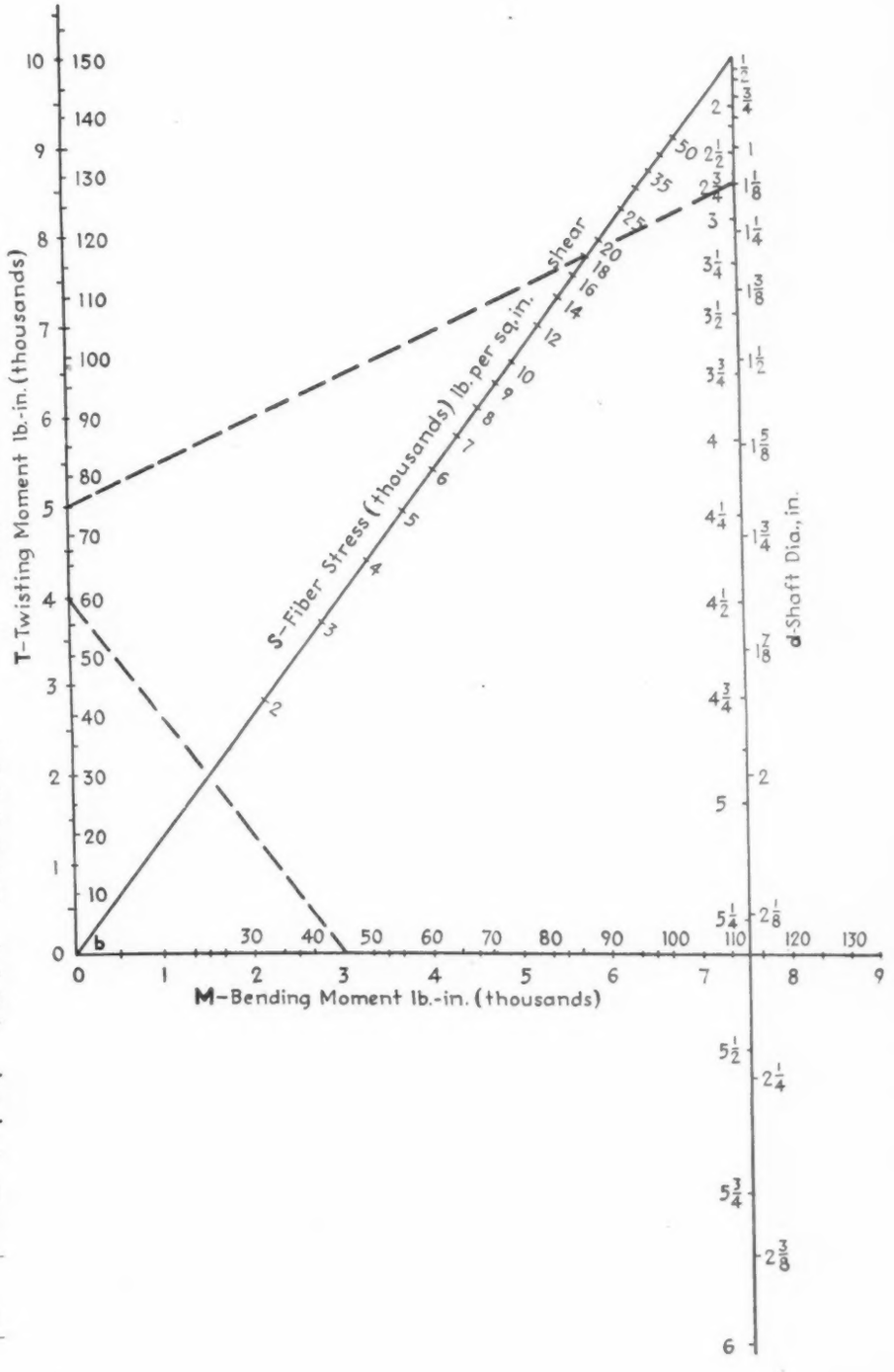
$$S = \frac{16\sqrt{T^2 + M^2}}{\pi d^3} = \frac{5.1\sqrt{T^2 + M^2}}{d^3}$$

The tentative Code for Design of Transmission Shafting of the A.S.A. recommends that the values of T and M used in this formula be obtained by multiplying the torque moment and the bending moment (as calculated by the usual method) by certain constants to take care of shock and fatigue. Table I gives these constants.

The A.S.A. tentative code further recommends that the working stress S be taken as 30 percent of the elastic limit in tension and not more than 18 percent of the ultimate tensile strength.

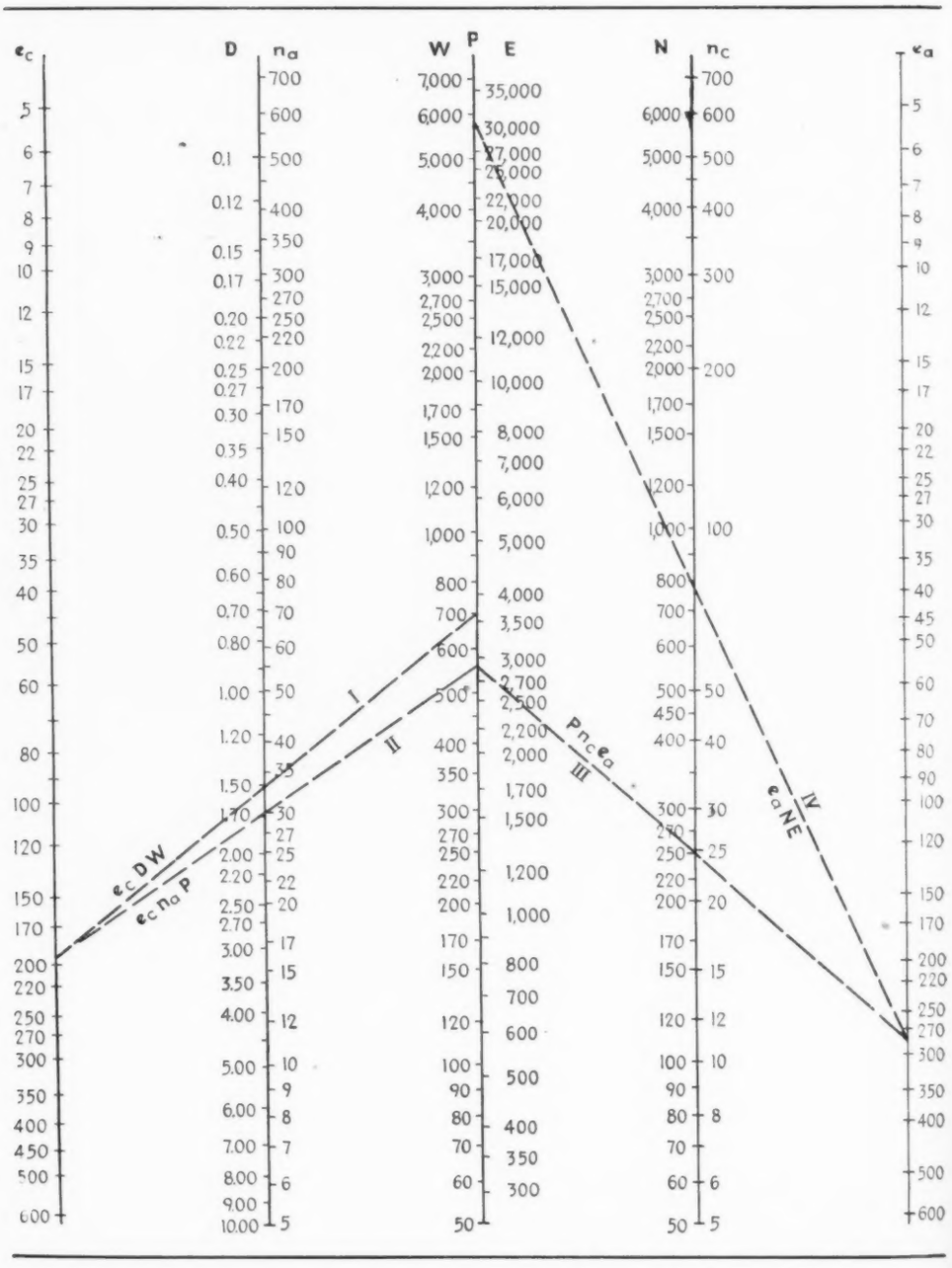
Table I—Shock and Fatigue Constants

Load Application	Multiplier for calculated torque moment	Multiplier for calculated bending moment
Stationary shaft		
Gradual	1.0	1.0
Sudden	1.5 to 2.0	1.5 to 2.0
Rotating Shaft		
Gradual or steady	1.0	1.5
Sudden, minor shocks	1.0 to 1.5	1.5 to 2.0
Sudden, heavy shocks	1.5 to 3.0	2.0 to 3.0



Nomogram for Kinetic Energy of a Revolving Body

CARL P. NACHOD
Nachod & U. S. Signal Co., Inc.



THIS compound nomogram is used in determining graphically the kinetic energy of a revolving non-homogenous body by the comparison solid method. The chart gives the relationship between the following factors.

E = the kinetic energy of the body in ft. lb.
N_a = number of torsional vibrations recorded in a given time when the body is suspended axially and twisted.
N_c = number of torsional vibrations recorded in the same period of time when the solid comparison cylinder is suspended axially and twisted.
N = the rotating speed of the body, in r.p.m.
D = the diameter of the solid comparison cylinder, in ft.
W = the weight of the solid comparison cylinder, in lb.

The following example is solved on the chart (see dashed lines).

EXAMPLE: What is the kinetic energy of a revolving armature when,

W = 700 lb.
D = 1.5 ft.
N = 800 r.p.m.
N_a = 30
N_c = 25

SOLUTION: Connect the D and W points on the respective scales with a straight line (Secant I) extended to the left scale. From here, draw Secant II through the n_a point to intersect turning scale P. From here, draw Secant III through the n_c point to the right hand scale. From this point, draw Secant IV through the N point to the E scale. The point on this scale cut by the Secant is the kinetic energy of the revolving armature, which, in this example, is 30,700 ft. lb.

The nomogram is constructed to solve the equations $e_c = 0.124\ WD^2$ in which e_c is the WR^2 factor of the kinetic energy of the solid comparison cylinder.

$e_c/e_a = n_c^2/n_a^2$ in which e_a is the WR^2 factor of the armature, and $E = e_a N^2/5872$ in which E is the kinetic energy of the armature.

PRODUCT ENGINEERING — REFERENCE BOOK SHEET